1983 NASA AUTHORIZATION

HEARING

BEFORE THE

SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

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[1] On assignment to Budget Committee for 97th Congress.

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February 17, 1982:

Dr. Jack L. Kerrebrock, Associate Administrator, Office of Aeronautics and Space Technology, National Aeronautics and Space Administration, accompanied by C. Robert Nysmith, Acting Deputy Associate Administrator, and Raymond S. Colladay, Director of R. & T. Division ..... Page 2

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1983 NASA AUTHORIZATION

WEDNESDAY, FEBRUARY 17, 1982

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON TRANSPORTATION,
AVIATION, AND MATERIALS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 2:10 p.m., in room 2325, Rayburn House Office Building, Hon. Dan Glickman (chairman of the subcommittee) presiding.

Mr. GLICKMAN. Today our subcommittee will continue its consideration of NASA's aeronautics program, in general, and its budget request for fiscal year 1983, in particular.

Last December, at a hearing called the first "A" in NASA, we asked a variety of witnesses about the cost effectiveness of NASA's longstanding partnership with the aircraft industry. We found unusually strong support. In fact, I think it is a fair statement to say it was unanimous. Everyone rejected the administration's idea that industry would, or even could, assume a greater share of the aeronautical R. & T. burden.

Yet, in spite of all the evidence to the contrary, the figures we received from the Office of Management and Budget persist in the direction that we have been heading in for some period of time now, which is a reduction in that commitment by Government. I think, in a shortsighted effort to save money, OMB directed NASA to terminate all technology validation except where a clear military application could be shown.

Now, it seems to me that this kind of wholesale withdrawal is counterproductive to everyone's desire for economic recovery. In fact, the first indications of this are already available.

A recent Commerce Department study shows that aerospace exports in 1982 actually will decline for the first time. Also, a concurrent 4-year trend in rising imports will result in a first-ever drop in the aerospace trade surplus. We thought that could happen in cars. Who ever thought it could happen in airplanes? And in one segment—general aviation—imports have already exceeded exports.

So the message is clear, the aviation industry is—not might, but already is—going the way of the U.S. auto industry. Now is not the time to experiment with one of our few economic winners. We have a system that works. We should be increasing our support to it, not tinkering with something that is vital to our economic well-being.

I would now like to call as our sole witness today, Dr. Jack Kerrebrock, Associate Administrator of the Office of Aeronautics and Space Technology within NASA.

Jack, I know that you have a prepared statement that you have sent to the committee.

Without objection, your entire statement will appear in the record. So you may read from part of it or do however you want to.

STATEMENT OF DR. JACK L. KERREBROCK, ASSOCIATE ADMINISTRATOR, OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY C. ROBERT NYSMITH, ACTING DEPUTY ASSOCIATE ADMINISTRATOR, AND RAYMOND S. COLLADAY, DIRECTOR OF R. & T. DIVISION

Dr. KERREBROCK. Thank you, Mr. Chairman. It is a pleasure for me to appear before you for the first time in my capacity as Associate Administrator. Accompanying me at the witness table is my Acting Deputy, C. Robert Nysmith. Also in attendance are my Division Directors who will be available to assist in answering any detailed questions which you may have that I am not able to answer.

Before proceeding with my presentation, I would like to introduce three people from the research centers who are spending a year with us at headquarters as part of the NASA career and executive development programs:

Mr. Lansing, from Langley Research Center, is working in the aeropropulsion noise area; Peggy Evanich, who is from Lewis, is helping in the management of the icing research activities; and Benton Parris, from Ames Research Center, is working in the area of simulation technology.

Mr. GLICKMAN. I promise you I will get out to Langley. I have seen the other two centers.

Dr. KERREBROCK. We will call you on that.

Mr. GLICKMAN. OK.

Dr. KERREBROCK. Not only are these people very helpful to us; but their managerial development is being broadened through the headquarters exposure so they can return to their centers with a better understanding of the overall decision process.

I do have a written statement which explains in considerable detail the funding distribution of our fiscal year 1983 aeronautics budget request and describes the work we propose to accomplish. The statement also describes some of our recent accomplishments and gives the status of the program authorized for fiscal year 1982. With your permission, I would like to submit the full written statement for the record and devote my oral presentation to a general characterization of the program and a description of the major changes and emphasis.

Mr. GLICKMAN. Without objection, your entire statement will appear in the record.

Dr. KERREBROCK. Our requested fiscal year 1983 research and development budget totals $232 million [figure 1], which is $1 million less than our fiscal year 1982 figure of $233 million. This budget will support a balanced research and technology base program, will allow us to maintain and operate the NASA aeronautical research facilities, and will permit continuation of a limited system technology program in support of national defense needs.

In keeping with the policy of this administration, we have given priority to fundamental technology over more applied system technology programs which require higher funding levels. The R. & T. base budget of $182 million continues to support a program whose principal objectives are to advance critical technologies and basic understanding in the major aeronautic disciplines of aerodynamics, propulsion, materials, and structures, guidance and controls, and human factors. The budget request for systems technology efforts for fiscal year 1983 has been reduced to $50 million. It retains efforts for rotorcraft and high-speed aircraft because of their importance to future military systems. However, systems technology focused primarily on commercial aviation needs have been terminated. We have included activities within the R. & T. base in the relevant disciplines to compensate for some of the more critical reductions.

The activities [figure 2] proposed in the fiscal year 1983 budget are divided into three major categories. The disciplinary research and technology includes our long-term activities which are relatively basic and broadly applicable to all vehicle classes. This accounts for 62 percent of the aeronautics budget. These efforts provide for the generation of a technical base for future civil and military aircraft and include research applicable to general aviation and transport aircraft. The work capitalizes on a strong blending of in-house NASA facilities and expertise with key university and industrial research capabilities. The vehicle class research and technology effort proposed for fiscal year 1983 is divided about evenly between the low-speed and the high-speed components. In both cases we have placed emphasis on systems technology relevant to military aeronautics consistent with the President's defense program. This emphasis is principally on rotorcraft in the case of the low-speed area, and high-performance aircraft in the case of the high speed.

Distribution of the proposed fiscal year 1983 R. & D. budget to the NASA centers is shown in figure 3. As the budget allocations illustrate, the bulk of the proposed program is conducted at Ames, Langley, and Lewis, with a very small fraction at other NASA centers. Each of these establishments represents a center of excellence in a number of technical disciplines. For example, aerodynamics at Ames, air propulsion at Lewis, and long-haul aircraft for Langley.

Each of the centers has a number of scientists and engineers, as well as unique facilities, which complement the resources of the industry, universities and military to form a national aeronautic research and technology capability. The capabilities represented by these research centers have taken decades to develop. We place a very high priority on their preservation, development and efficient utilization for both the civil and military sectors of the U.S. aviation industry.

While I am discussing the NASA centers, I would like to explain briefly the impact of a reorganization [figure 4] of headquarters which was implemented last December. The center directors now report directly to the Associate Administrators who are responsible for most of the programmatic activities of their reporting centers. The Associate Administrators have responsiblity for and authority over all institutional resources and activities related to their cen-

ters. I have institutional responsibility for the three research centers: Ames, Langley, and Lewis.

In coordination with the center directors, I will formulate and have overall management responsibility for their construction of facilities [C. of F.] and research and program management budgets. This reorganization assures that strong centralized management direction will be given to both programs and institutions. I believe this management structure will help us successfully meet the challenges which we must face in an environment of budget constraints. The magnitude of the added institutional responsibility at the three research centers is compared to my continuing responsibility [figure 5] for R. & D. and R. & P.M. The R. & P.M. budget provides for 7,345 civil service positions at the research centers. Nearly 68 percent of the OAST institutional and R. & D. budgets are applied directly to aeronautics research and technology. The R. & P.M. budget applied to aeronautics supports 3,764 positions.

In summary, while there are some technology challenges that will have to go unmet if the private sector does not continue systems technology efforts aimed at commercial applications, we feel the fiscal year 1983 budget will permit a valuable aeronautics program. We will be maintaining the capability to respond to systems technology needs in the future, and we will continue to advance the technology base in all key aeronautical disciplines. With the strong support of this subcommittee, Mr. Chairman, we have over the years built an aeronautical research program of which we can all be proud. We intend to sustain this effort to the best of our ability and to meet as many objectives as possible.

Mr. Chairman, this concludes my overview remarks. I would be pleased at this time to continue with the highlights of a few specific activities proposed in the fiscal year 1983 budget, or we could let the written statement suffice for that purpose and I could respond to your questions.

Mr. GLICKMAN. Why don't I get to some questions?

Let me first ask you, in your statement you talk about, I guess, a change in philosophy on the systems technology work, which really allows funding for those programs only where a clear military application exists. I may be putting words in your mouth. But you talked about rotocraft and high speed as two of the areas that would receive the bulk, if not all, of the system technologies funding. But there are other programs that will, of course, not be funded. At least in the systems technology work.

Programs such as propfan, composite structures, tilt rotor, and others, I think, have been listed historically.

Now I wondered if you would comment on two things: One, why did you pick the ones to stay in, the rotorcraft and high speed, at the expense of these other ones, and, two, how much of this work will be done in the R. & T. base? How much can be picked up in the R. & T. base that was not already there before?

Dr. KERREBROCK. The answer to the first question is that the systems technology programs that were selected for continuation are the ones that have the most clearly definable applications to military needs. In the case of the low-speed work, the rotorcraft effort is connected very tightly with the Army's program at Ames Research Center. In the case of the high-speed work, most of the pro-

grams are focused on military high-performance aircraft of one kind or another.

The answer to the second question is somewhat more difficult. As you know, there was an OMB guideline that NASA's systems technology programs which appeared to have their principal application to civil aircraft, such as the ACEE program, should be supported in the R. & D. phase by the industry which will profit from their application. It is possible that the full importance of these programs for the military was not appreciated in the budget climate of last fall, so that the degree of their applicability to military programs may have been underestimated.

Mr. GLICKMAN. The degree of applicability of these other programs, you are saying, may have been underestimated?

Dr. KERREBROCK. Yes; but in the decisionmaking process, the key factor was their dominant applicability to commercial programs.

Mr. GLICKMAN. You know, I have received a copy of a part of a document from the Department of Defense. It's called their military critical technologies list. The part I have is unclassified. Basically, it is prepared, as you probably know, on an annual basis, and it describes what kind of technology needs they think need to be met.

It is interesting that as a part of their needs—and you may have alluded to this before—they list things like advanced propeller technology. They list laminar flow control technology. They list propulsion, system configuration, aerodynamic and thermodynamic analysis technology, turbine technology, a lot of the things in the energy-efficiency program.

What I am saying is, the Defense Department itself has prepared a list of militarily critical technologies in which they list things like the aircraft energy-efficient program.

Most of what you were doing, in the systems technology area even falls within the military's list of things they consider to be important. But I gather from what you are telling me is that OMB prioritized what they felt was most important, and OMB came back with a couple of things they wanted at the expense of the other things?

Dr. KERREBROCK. I believe that was the intent of the negotiations last fall. But, as I tried to indicate, it may be that that intent was not realized fully because of the character of the discussions.

Mr. GLICKMAN. OK

Dr. KERREBROCK. Which was somewhat hurried and less than deliberate.

Mr. GLICKMAN. The reason why I ask that is because I would like to be in a position to talk with people in the Defense Department. They themselves came to this committee rather indirectly through correspondence, as you know, to Mr. Stockman, and strongly supported the aeronautics program.

Basically, I think it is important that, if there are other things which are important to the Defense Department, then we ought to know that. I think that is something that we need to clarify from them before we come up with a budget.

Dr. KERREBROCK. So far as I know, there is no hard Department of Defense requirement for either the propfan or the laminar flow control technology. However, if these technologies were available,

it seems likely that they might find their way into future military systems.

The NASA composite structures program, in particular the large composite structures program, is the base program in that area for the Nation and does not have a counterpart in the Department of Defense as far as I know. Composite technology is important for all large aircraft. So that, again, it would have direct applicability to future military systems if brought into being. The energy-efficient engine technology is, at least in the component form, already finding its way into engines for military systems. I need to mention that the tilt rotor is a prime contender for a military medium-lift system in the near future which is not, of course, part of the ACEE program.

The other part of your question was to what extent the work that is not being done under the civil-oriented systems technology programs will be carried in the R. & T. base. I believe the best answer I can give to that is, the more fundamental work, which is conducted to a considerable extent by in-house personnel and by low-cost contracts and grants, will continue to develop the technology base in all of these areas. The work that wouldn't be done is the more expensive contracted work with industry, which produced hardware demonsrations and systems technology verifications.

Mr. GLICKMAN. If I may followup for a minute, I have mixed feelings about the concept of your doing systems technology work that has direct military application, at the expense of civil application, from two sides. One is that I am wondering whether NASA is becoming, as its primary function, a systems support agency for the Defense Department, in which case we ought to call it that, and shift those funds in the Defense Department.

On the other hand, I am aware—and the committee has information—that the health of basic military research and technology programs within the Defense Department is not very good, because what they are doing with their research and technology dollars is buying hardware, and not doing basic research.

So what I am wondering is, is NASA being used as a place to do some military research and technology work that they ought to be doing themselves, but can't because of other budgetary problems within the Department of Defense?

Dr. KERREBROCK. Two comments, first, I believe it is correct to say that NASA is not in the position of doing systems technology work in support of DOD in place of systems technology work for the commercial sector, but rather that a continuation of systems technology work in support of the Department of Defense has been allowed, whereas a continuation of systems technology work in support of the civil sector has not been allowed under the present administration's guidelines. NASA has always had a very strong role in the research and technology base in support of the Department of Defense, as well as the commercial sector. We feel that is an important part of our charter, and we would hope we can continue that.

I do believe that there is some tendency for the increase in the defense spending to be concentrated on hardware procurement. I am not sure there is actually a cutback in research and develop-

ment funding, but that may well be. I don't have their exact numbers.

Mr. GLICKMAN. You mean in the defense budget?

Dr. KERREBROCK. Yes, sir.

Mr. GLICKMAN. I think there is an increase in the R. & D. function of the defense budget. It is just that our information is that it may not be going for classic R. & D. It may have more of a procurement element to it, in which case the R. & D. is not being done. That was my only point. I am not sure there is anything we can do about that right now. Perhaps we may want to get some DOD people in here to talk about that issue.

The other thing I was going to ask you is in reference to the propfan, which may have sustantial application in the military. Are you aware that any of the work that you are cutting back in systems technology is being substantially enhanced by other governments in other countries?

For example, I am aware the French are moving ahead rather dramatically with advanced propeller technology. Was that a part of your thinking in the systems technology work when you decided not to fund at all?

Dr. KERREBROCK. No, sir. Specifically in the case of the propfan, it was not a consideration. Our deliberations there focused entirely on the technological and economical promise of the propfan rather than on any possible foreign competitive situation. To my knowledge, no foreign company or government has displayed an interest in the propfan, to the extent of having launched a program to develop one.

Mr. GLICKMAN. Yes; my information indicates that manufacture of a propfan model and its test are planned for 1984 in France. Now, to what extent that is a significant program, I am not sure.

I guess the main question I am asking is whether the programs that you have cut back in systems technology, can be adequately handled within the R. & T. base in the face of an increasing competitive threat in aerodynamic research throughout the world?

Dr. KERREBROCK. The threat is not in research, but in systems technology and development. The administration's position is that that threat will be handled by private enterprise. For example, in the case of the large composite structures program, if there is a sufficient economic motivation for incorporating that technology in a future large transport, one of the large transport manufacturers will face up to the research and development requirements.

There is a threat, a serious threat, of competition in that particular area from airbus industries. We do not know to what extent they have committed themselves to the incorporation of that advanced technology in, I guess, the 320.

Mr. GLICKMAN. What is that, the second model after the 300?

Dr. KERREBROCK. Probably.

Mr. GLICKMAN. Second generation.

Dr. KERREBROCK. Yes, the Airbus 320.We do not know the extent of their commitment; but, there is a potential that they may do it.

Mr. GLICKMAN. Realizing that your job is not one in which you set the aggregate policy that the administration is pursuing, I have some concerns after reading the Seattle paper, the Los Angeles paper, and the Wichita paper, about whether the private sector can

in fact do what the administration wants it to do. And perhaps our committee will have to deal with that issue as we mark up the bill.

Let me move on to some specific issues. You showed us the viewgraphs of the budget for Lewis, Ames, and Langley. I have the numbers of direct civil service positions at each of the three major centers. Are all of them fairly secure in terms of being operational entities in the near future?

Dr. KERREBROCK. Insofar as their participation in their basic activities of aerospace R. & D., I feel they are quite secure in their manning for fiscal year 1983. There have been some manpower cuts for the agency. The largest cut is at Lewis. Lewis must reduce 211 positions by the end of fiscal year 1983; that is, over a 2-year period.

Mr. GLICKMAN. Lewis had some of the system technology work, engineering?

Dr. KERREBROCK. That is correct.

Mr. GLICKMAN. In terms of its effect on the actual operations, will any of these cuts have much of a dramatic effect?

Dr. KERREBROCK. A reduction of 211 from a total level of 2,690 at Lewis can be accomplished by attrition; thereby minimizing the dramatic effect of a reduction. There is a problem, however, with continued attrition of the manpower at the NASA research centers.

Mr. GLICKMAN. I am going to move back to fiscal year 1982. Your fiscal year 1982 operating plan was changed rather drastically without congressional review. Pending this review the Appropriations Committees in both Houses of Congress directed you not to implement the 1982 plan in a way that would preclude funding of the aeronautics program at the level assumed by the appropriation.

In spite of this, I understand you are issuing stop work orders to some of your contractors. I wonder if you could explain.

Dr. KERREBROCK. Mr. Chairman, we have submitted the fiscal year 1983 budget which budget also contains the current fiscal year 1982 budget which is consistent with the agency operating plan. We have taken some actions which we consider prudent in order to execute the fiscal year 1982 aeronautics program in accordance with this plan. The actions taken are not irreversible. If additional funding becomes available, the programs curtailed could be reinstated.

Mr. GLICKMAN. That was my next question. The committee may be interested in restoring the funds for certain civil systems technology programs. And through contacts with Members of the other body, I think there is some interest there too. I just want to make sure that your actions in the 1982 operating plan don't foreclose continuing some programs that we may direct you, through the authorizing appropriations process, to continue.

Dr. KERREBROCK. We have taken every care to insure that that was the case where we could. I am sure you appreciate that in order to meet the fiscal year 1982 spending limit that we see now, we do have to take some actions.

Mr. GLICKMAN. I wonder if you might tell us what actions that you have taken in some of the main systems technologies areas.

Dr. KERREBROCK. We have discontinued the work on the wing structure for the laminar flow control program, for example. I will

either have to call on Ray Colladay for more detail on that, or we will have to get back to you. Do you have a list of the actions, the actual commitments, at this point?

Dr. COLLADAY. I think the item just mentioned on laminar flow control, is the only termination we have made. However, we are in a continuing dialog with the major contractors to be in a position to act on other contracts if we have to. But, at this point we are just looking at realinement options that could be exercised at some point downstream. There are no other commitments that I know of.

Mr. GLICKMAN. What you might do for the committee's record, when you get a chance during the next week, unless it is otherwise in your testimony, if you could drop me a line indicating exactly what you told me, like what you plan to do during the rest of the fiscal year in terms of some of these systems technology programs so that we at least know what the facts are. When we come to mark the bill up, it would be useful to us.

Dr. KERREBROCK. Yes, I see. We can tell you what our planning is. Dr. Colladay's answer was that there are no commitments other than the one that I mentioned.

Mr. GLICKMAN. Yes.

Dr. KERREBROCK. Of course, we are having discussions with people. And, you would like to know what those alternatives are that are being discussed; is that correct?

Mr. GLICKMAN. Yes.

Dr. KERREBROCK. Yes, right. We will do that.

[The information follows:]

As a result of an Administration policy, NASA systems technology programs which provide focused technology applications principally to civil aviation will be phased out in FY 1983. Consequently, NASA has been engaged in planning activities on how best to accomplish this while striving to achieve to the greatest extent possible the original goals of the affected programs or the most efficient limited goals attainable within budgetary restraints. Our FY 1982 Operating Plan and the FY 1983 budget request reflect this planning. The actions taken so far in FY 1982 in implementing the Operating Plan are not irreversible and do not preclude reinstatement of programs which are being curtailed or descoped. Planning is continuing and additional actions will have to be taken before the end of FY 1982 in order not to exceed the FY 1982 spending limits that we now face.

As stated earlier, the only contract terminations that have been consummated to this point are two contracts in the Laminar Flow Control (LFC) program for the design and development of an advanced technology LFC wing surface structure and the attendant LFC subsystems. Although some additional stop work orders will have to be issued before the end of FY 1982, there have been other internal actions such as the withholding of planned requests for proposals, deferments, and descoping of programs.

The Advanced Turboprop (ATP) program is a typical example of the actions which are being taken in the civil-oriented systems technology programs. Major procurements in FY 1982-1983 of largescale blades and drive systems for ground testing must be descoped or deferred. Only limited research can be conducted on large-scale advanced propellers which exhibit full-scale structural and aerodynamic characteristics and provide data for subsequent civil and military aircraft. The planned work in acoustics and installation aerodynamics must be limited in order that subscale investigations of propeller or propfan technology may continue. Contracts for large-scale ground experiments cannot be undertaken in the phase-out program.

In the Energy Efficient Transport (EET) program, stop work orders will have to be issued within the next 30 days covering the second phase of a two-phased activity to apply an active pitch control system to a transport aircraft. Exploratory studies in the All-Electric Airplane technology area will have to be deferred to some later date.

The planned stop work orders to be executed in FY 1982 in the Energy Efficient Engine (EEE) program will terminate first and second tests of integrated core/low spool at Pratt and Whitney Aircraft Company and the second test of integrated core/low spool at General Electric. The stop work order to Pratt & Whitney, which is imminent, eliminates the evaluation of systems technologies and component interaction and will focus the remainder of the program on component technology. At General Electric, the remaining effort will complete the component technology effort and normal systems evaluation including core test and first integrated core/low spool test.

The Composite Primary Aircraft Structutes program will be affected by the present FY 1982-1983 budget plan in two ways. First, premature failures on the medium-primary structures program will force the issuance of stop work orders before April 1982 for work previously planned. The most probable tasks to be deleted include the assembly and flight checkout of the DC-10 composite vertical stabilizer which was planned to support certification by the FAA. The second effect will be in the key technology programs which are investigating issues critical to highly-loaded composite wing structure including fuel containment, damage tolerance, and thick joints. Stop work orders will have to be issued before August 1982 to terminate Phase Two efforts which include small-scale element tests supporting the development of design allowable data.

Mr. GLICKMAN. One of the things that was on the drawing boards for a long time was the numerical aerodynamic simulator. This was a high priority of NASA at one time, as recently as last year. What is the status of that?

Dr. KERREBROCK. Numerical aerodynamic simulator [NAS] is still a high priority, even though it is not a new start in the fiscal year 1983 request. The current status of it is that two contractors are preparing proposals for a two-part phase C/D effort, which would, if we elect to go ahead with full-scale development, begin in fiscal year 1984 as a new start. The program would be carried through fiscal year 1983 with money in the R. & T. base.

Mr. GLICKMAN. And then theoretically at some time you will come to us with a recommendation that we begin the procurement process?

Dr. KERREBROCK. Yes; after we review the proposals, if the decision is made to seek the procurement of the full system, then we would, of course, come to you to ask for a new start in fiscal year 1984.

Mr. GLICKMAN. To what extent are our friends throughout the world moving ahead with computational research and simulator development?

Dr. KERREBROCK. As far as I know, no one has made a commitment to a direct counterpart of the numerical aerodynamic simulator. However, the Japanese have made a serious commitment to advanced computers; that is, one technology step advanced beyond the class 6 computers, commonly called "super computers." They are not specifically targeted at the application that we have in mind for the NAS.

Mr. GLICKMAN. I recall when I was out at Ames we had an extensive discussion with some of your people out there in reference to this. They felt this was a high priority. In fact, you had some difficulty convincing members of this committee over a period of years that this was something we ought to move ahead on at the expense of something else.

And now I have come to believe that this is one of the areas of greatest threats to us. I guess I got the feeling from going to the Ames Center that the Japanese were moving ahead rather quickly in this area.

Dr. KERREBROCK. Mr. Chairman, we feel the NAS, or the computational capability which we characterize by NAS, is absolutely essential for NASA and for the future of the aeronautical industry in the United States. It represents the next logical development of technological competence to design aircraft with an increased degree of precision, with reduced cost and better performance per dollar. In that sense, it is absolutely essential for NASA to go ahead with it. What I meant to say was that I am not aware that any foreign country has yet made the commitment to apply that kind of competence to aeronautics. They have been quite aggressive in procuring "super computers," or class 6 computers, and applying them at the state of the art.

Mr. GLICKMAN. I was in Japan last January with this committee. We met with their Ministry of International Trade and Industry people. MITI has a 10-year operating plan about the future of aeronautical development, yet when we went into our Embassy and

talked to some of our Embassy people, they said we had no real belief the Japanese are going to move into development of aircraft.

But when we went to talk to the Japanese it was very clear that they were very interested. So our people, as usual, didn't have any basic intelligence about what was happening in the country.

But what concerns me is that we, in this budget, are reversing a longtime Government policy of supporting both research and technology validation at a time when our industry is losing ground to foreign competition?

Dr. KERREBROCK. Mr. Chairman, it is the view of our advisers that this is the wrong time to cut work in either research or systems technology programs. With regard to technology validation, which we consider to be the last step before production commitment, only a few NASA programs have been or are in this category. Some examples are composite primary aircraft structures, engine component improvement and the materials for advanced turbine engines program.

Programs such as these are the key to technology transfer in that no further technology development is required before application. In the minds of many within and outside of NASA, more programs such as these are the key to staying ahead of foreign competition. It is the administration's policy, however, that such programs shall not be conducted in support of civil aviation.

Mr. GLICKMAN. These advisers that you talk about, do they believe that the private sector will continue with this research and technology? Or are these advisers part of the industry?

Dr. KERREBROCK. The opinions they express, I think, could best be summarized by saying that the commercial aircraft industry at the present time is financially strapped, even though they have a rather large cash flow. In addition an investment or at least an increase in long-term research is difficult for them at this time. Therefore, they are concerned about NASA withdrawing from this kind of work.

Mr. GLICKMAN. This morning's Wichita Eagle reported that Cessna laid off about 1,200 workers in Wichita. And I think the handwriting is on the wall that we are going to see further layoffs.

I guess my point is that I am not sure any research and development or systems technology work, per se, or anything else is going to make any difference in the short term. But it is absolutely clear to me that there is not the financial resource base to continue with a lot of their work at the same levels they have been doing in the past. And the signal that we send to the rest of the world has to be a very mixed signal, that Government's commitment to do some of that basic research is, if not ending, is shifting in direction to some degree.

And I don't know how this subcommittee is going to feel when we look at this budget. I have not talked to any of the other members. But it looks to me as if we are going the same way as the auto industry. Whether increasing systems technology work is going to prevent that, I am not sure. But I think given the guidelines that you have had to come up with, that you have been instructed to deal with, you have probably done a reasonably good job.

I am not faulting or criticizing you or Mr. Beggs or Dr. Mark. I am just saying I am getting one message from the administration, when I talked to Dr. Keyworth. I see another message when I see the budget we finally end up with.

All I want to make sure from your perspective is that you recognize the growing international problems we have with competition and development of a resource base that has been unequaled in the rest of the world, and that Congress may do something to try to deal with that issue the best we can.

I wanted to get into some other areas, too. Our committee is going to have, along with another subcommittee, some hearings on aviation safety. I am not sure you know about this yet. I am not sure how much of it is in your area. Will your budget changes—you do a lot of work in human factors, icing, flammability, a variety of issues, crashworthiness—will any of those programs be affected up or down by this budget?

You can respond generally. We will probably have you back in during those hearings to deal with more specifics, but I am just curious about this.

Dr. KERREBROCK. Yes, Mr. Chairman. FAA has the major responsibility for improving aviation safety, and it uses NASA research to upgrade its standards, procedures and crew performance, and in the process of the rulemaking, in particular. We formally coordinate through a NASA-FAA Coordinating Committee many programs within NASA; and, in fact, FAA transfers some funds to NASA to support unique facilities which we have in some of these areas. Some examples of NASA research which is coordinated with the FAA in safety are work on fire safety, combustion of aircraft interior materials safety fuels, and crash impact dynamics. An example of this cooperation is a joint program to enhance occupant survivability by a deliberate crash in 1984 of a surplus Boeing 720 aircraft to validate anti-igniting kerosene safety fuels and to study the crash dynamics of the fuselage and critical components such as seats and seat restraint systems. We also conduct crash dynamics research for general aviation.

The study of clear air turbulence, wind shear, icing, and runway traction are also very important areas. We have also done work on high altitude ozone transportation. We are currently doing work on lightning effects on aircraft systems, wake vortex alleviation, which is a key factor in the spacing intervals between aircraft and limits airport capacity. This work will total about $9 million in 1982 and about $10 million in 1983.

Mr. GLICKMAN. I know you also have the service where pilots and airplane operators can get you confidential information.

Dr. KERREBROCK. Yes; the aviation safety reporting system.

Mr. GLICKMAN. I think people feel more secure with you having that because you are not involved in the regulatory process, and you collate that data, publish it, and make recommendations, and that kind of thing.

Again, we are going to ask you probably to come and testify in another 3 or 4 weeks on the issue, but it would be useful to know what you are planning in 1983 vis-a-vis what you have had in 1982 on aviation safety-related issues, human factors, and other kinds of things.

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Dr. KERREBROCK. We will describe what we are going to incorporate in the R. & T. base during that hearing; however, we provide some information. The other one, which is very important to the FAA, is the human factors area, which is about $8 million in fiscal year 1982. The human factors area includes flight management, cockpit display of traffic information, simulation technology, circadian disynchronous cockpit automation, crew workload measurements, and community response to transport noise. We are going to continue all of those programs within the human factors R. & T. base program.

We are presently looking at the disposition of the terminal-configured vehicle program. We want very much to continue that; however, it will depend on our funding priorities, whether we can reprogram to support it.

[The information follows:]

The funding included in the aeronautics research and technology base program for aviation safety and human factors research is as follows:

[In millions of dollars]

	Fiscal years	
	1982	1983
Aviation safety	9.1	10.1
Human factors	8.0	9.6

Mr. GLICKMAN. Have any programs been curtailed or are any going to be curtailed upon which the FAA depends for its ability to manage the national airways system and assure safety of the air transportation system? As you know, they are in the process of coming to the Congress for both program authority and funding authority for modernization of the entire air traffic control system and they depend on you for much of the base information.

Dr. KERREBROCK. Mr. Chairman, my understanding is that decisions have been made or are likely to be made on reequipping the air management system, the airway system. The decisions are pretty much based on technology which is now in place. Our contribution to the FAA is in technology further in the future. Our role at present in the air traffic control system has been centered principally on flight-vehicle and flight management technology rather than on the equipping of the air traffic control system. This is not to say that a reduction in our efforts would not impact the system in the future, because certainly it will continue to evolve. I will provide some additional information.

[The information follows:]

There are, however, several system technology programs that are being terminated which are contributing substantially to a data base for FAA use in defining aircraft airworthiness standards, establishing operating procedures, and increasing productivity of the National Airspace System. Specifically, the terminal configured vehicle program is being conducted under a joint cooperative agreement with FAA in defining functional requirements and performance criteria for flight systems and displays of the future with which the pilot can safely and efficiently operate in the evolving National Airspace System. The Composite Primary Aircraft Structures program provides design data and a base of knowledge to FAA for its role as aircraft certifying agency. The Energy Efficient Transport program supplies a similar tech-

nology data base and understanding in establishing certification criteria for flight critical avionics systems such as active controls and digital avionics. These examples relate to transport aircraft. Similar activities occur in support of general aviation.

Mr. GLICKMAN. But to the extent that you know now, you haven't been told by the FAA or you haven't discovered internally that any potential program cuts would affect their new plan.

Dr. KERREBROCK. No; because Mr. Helms is in the process of putting in place the decisions on that plan. This plan uses the information which is now in hand.

Mr. GLICKMAN. I want to go back to another area that I touched on in DOD. Both NASA and DOD have told us that the Department of Defense relies heavily on NASA transport R. & D. for future military cargo, patrol bomber, and tanker aircraft; that is, really, aircraft with more acute civilian likeness and other types of aircraft.

How do you propose to provide this necessary support to the Department of Defense now that your budget basically abandons the general area of research in the systems technology area?

Dr. KERREBROCK. Mr. Chairman, I believe that to the extent that the Department of Defense was depending on the technology spinoff to military systems from programs that we were conducting, primarily for commercial application, that that technology will be missing. The direct impact of that on military systems is not clear to me at this time, because it is not clear to me exactly what military systems are likely to be procured in the near future and to what extent they would use those particular technologies that we were pursuing, with the possible exception which I have already mentioned of the large composite structures program. If the military did decide to procure a large transport or bomber-type aircraft, then it would find that that technology would be very useful. We will continue to do the generic aerodynamics work, and we will continue to work on the base technologies of aircraft propulsion, so that we are not abandoning the field completely.

Mr. GLICKMAN. Let me move for a moment to general aviation. NASA appears to be drastically reducing and perhaps discontinuing its research on improving general aviation safety, efficiency, and utility. Have these needs been satisfied? Do you think that the general aviation industry is capable of conducting the research NASA still considers necessary?

Dr. KERREBROCK. No, sir, I think there will always be needs for the incorporation of better technology in general aviation aircraft. If we could divide those aircraft into the different categories, it would be easier. For the light aircraft of the four- to six-passenger categories, say, Cessna, Beech, and so forth, there is a particular need for a new engine which can operate on aviation kerosene. We are placing increased emphasis on that sort of work in the NASA budget.

NASA has been doing considerable work on the crash dynamics of such light aircraft. We will continue to work in that area in modeling in an attempt to generate information for the design system.

Mr. GLICKMAN. What about the commuter area?

Dr. KERREBROCK. Commuter aircraft is the second category that I wish to mention. The majority of the balance of payment shift,

which we have seen in the general aviation area, is due to the import of relatively small numbers of rather expensive aircraft of the computer type in opposition to the export of rather larger numbers of much less expensive smaller aircraft. The technology for those aircraft is not at the level of the transport aircraft that we are using now. So, there is a need for advanced technology in that area. It is probable that if we could provide advanced levels of technology to manufacturers in the United States, they would be in a better position to compete in that area.

Mr. GLICKMAN. I think one of the things that we ought to do as a committee probably, before we mark up this bill, is to pursue the issue a little bit more with the DOD as to what their needs are, because we have some different signals coming from some of the high-level folks thereabout what their needs are, and also pursue with you some priorities.

I personally think that we are heading in the wrong direction in this area, but the majority of the committee will prevail in determining whether we want to add any money. But given the deficit issue, we may decide to redirect some of the money that is in there, and we will look forward to working with your staff on this issue.

I don't want to see any more newspaper stories in my district. I have lived 5 years with low unemployment in the aeronautics-aerospace industry, and it looks to me like it is turning back again; and realizing nothing we can do here is going to change that overnight, I am worried about it 5 and 10 years down the road.

If there are no other comments we will declare this hearing adjourned.

Thank you.

Dr. KERREBROCK. Thank you, Mr. Chairman.

[Whereupon, at 3:15 p.m., the subcommittee was recessed.]

[The prepared statement of Dr. Kerrebrock follows:]

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PRESENTED BY WITNESS
FEBRUARY 17, 1982

Statement

of

Jack L. Kerrebrock
Associate Administrator for
Aeronautics and Space Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Transportation, Aviation
and Materials
Committee on Science and Technology
House of Representatives

Mr. Chairman and Members of the Subcommittee:

I am pleased to appear before you today to present the proposed NASA Fiscal Year 1983 Aeronautical Research and Technology program and budget, testifying for the first time in my capacity as the Associate Administrator for the Office of Aeronautics and Space Technology (OAST).

Before proceeding with my presentation, I wish to compliment you on your efforts to focus attention on the importance of NASA's Aeronautical Research and Technology program to the national economy and to national security. The "First 'A' in NASA" hearings that you held last December produced a clear consensus from representatives of the aerospace industry that the NASA Aeronautical Research and Technology program is vital to the long-term health of United States aviation in both the military and the civil sectors. I believe that assistance of this nature from the Congress is critical to the preservation of a vital national capability which has evolved over more than a half century: a unique combination of NASA, industry, military and university scientific and technical capabilities, collaborating to produce advanced aeronautical technology.

Within the Administration's guidelines for Federal spending and its philosophy for R&D support, we have developed the FY 1983 Aeronautical Research and Development (R&D) budget request of $232M. This request consists of Research and Technology (R&T) Base and Systems Technology elements. The FY 1981-1982 R&D budget history, and the division of the FY 1983 budget request are shown in Figure 1. The R&T

Base budget continues to support a program whose principal objective is to advance critical technologies and basic understanding in the major aeronautical disciplines of aerodynamics, propulsion, materials and structures, guidance and controls, and human factors. The budget has been substantially reduced as a result of termination of systems technology programs focused primarily on commercial aviation needs in which it appears appropriate for the private sector to play a larger role. However, systems technology efforts for rotorcraft and high-speed aircraft have been retained because of their importance to future military systems.

The activities proposed in the FY 1983 budget request are divided into three major categories as indicated in Figure 2. The disciplinary research and technology, which accounts for 62 percent of the total budget, primarily consists of long-term activities which are relatively basic and broadly applicable to all vehicle classes. This is high-risk, relatively fundamental work, critical to the generation of a technology base for future aircraft -- civil or military. It capitalizes on the unique blend of in-house NASA facilities and expertise, the university research community and the research capability in industry. The vehicle class technology effort for FY 1983 is divided about evenly between the low-speed and high-speed aircraft classes. Primary emphasis is being placed on advanced rotorcraft concepts and on high-speed military aircraft.

While most disciplinary work is funded from the R&T Base budget line, some is also carried in the systems technology elements of the budget. Similarly, some of the vehicle-class work is funded through the R&T Base line.

The facilities which NASA operates for the national aeronautical community, and the collection of technical expertise represented by the staffs of its Research Centers, play a vital role in the Nation's aeronautical research and development process. This capability has taken decades to develop and is a major national resource. We place a high priority on its preservation, development, and efficient utilization for both the civil and military sectors of the United States aviation industry.

The major roles of the Research Centers and the allocation of the FY 1983 Aeronautical R&D budget request are depicted in Figure 3. The bulk of the budget is distributed to the Ames Research Center, the Langley Research Center and the Lewis Research Center. Each is a center of excellence in one or more technical areas, having expert scientists and engineers as well as unique facilities. The NASA Centers complement the resources of industry, the universities, and the military to form a national capability in aeronautical research and technology.

During FY 1983, four new research facilities important to the accomplishment of our aeronautics research and technology program goals will come on line. These facilities

are the National Transonic Facility (NTF) at the Langley Research Center, the Avionics Integrated Research Laboratory (AIRLAB), also at the Langley Research Center, the 80x120-foot wind tunnel, and the Man-Vehicle Systems Research Facility (MVSRF) at the Ames Research Center. The NTF is a cryogenic wind tunnel which will provide the Nation with the world's most advanced high Reynolds number facility. It will make available wind tunnel data at higher Reynolds numbers than heretofore achievable. The AIRLAB is an electronics research laboratory which will be used to perform research in advanced aircraft control, data distribution systems, and highly reliable fault-tolerant control systems. The 80x120-foot wind tunnel will allow for the testing of full-scale vertical and short-takeoff and landing aircraft including large rotorcraft in the speed range of 5 to 100 knots. The MVSRF is a simulation facility which will provide full mission, ground test simulation of multiple aircraft, terminal area air traffic control and aircrew interactions, and advanced technology cockpit displays representative of future generations of aircraft. It will uniquely satisfy a national requirement for aeronautical human factors research.

While we are discussing the NASA Centers, I would like to explain the impact of the reorganization at NASA Headquarters which was implemented last December. The objectives of the reorganization were to establish a clear distinction between line and staff functions and to improve the utilization of the NASA Centers. The Center Directors now report to designated Associate Administrators who are also responsible for most of the program activity at the Centers. The designated Associate Administrators have responsibility for and authority over all institutional resources and activities related to their Centers. The overall structure is shown in Figure 4. As you can see, I have the institutional responsibility for the Ames Research Center, the Langley Research Center and the Lewis Research Center. In coordination with these Centers, I will formulate and have overall management responsibility for their Construction of Facilities (CofF) and Research and Program Management (R&PM) budgets. The reorganization assures that strong, centralized leadership will be given to the programs and activities the Centers undertake. I believe that this management structure will help us successfully meet the challenges we must face in an environment of severe budgetary constraint.

The magnitude of the added institutional responsibility at the three NASA Research Centers is compared to my continuing responsibility for management of the Aeronautics and Space Technology R&D programs in Figure 5. As shown on the right, more than 60 percent of the OAST institutional and R&D budgets are being applied to aeronautics R&T. In addition to these direct appropriations to NASA, there is also a small reimbursable activity funded primarily by the Department of Defense (DOD) which supports our aeronautics program.

The aeronautics facility needs included in the CofF request include modifications to the Transonic Dynamics Tunnel and the 4x7-meter Low Speed Tunnel at the Langley Research Center and modifications to the Engine Research Facility at the Lewis Research Center. The modifications to the Transonic Dynamics Tunnel will increase the density range of the tunnel test medium by 50 percent and enable scaling of key aeroelastic parameters for current and anticipated future aircraft designs. The modification to the 4x7-meter Low Speed Tunnel will increase the operational efficiency and productivity of the tunnel and provide reduced occupancy time for model installation and calibration. The modifications to the Engine Research Facility will provide a new air compressor to the facility which will produce compressed air flows that significantly exceed the capacity of the present air compression system.

I will now briefly discuss the proposed programmatic activities included in the FY 1983 Aeronautical Research and Technology R&D budget request. My discussion will follow the categorization of activities by Disciplinary Research and Technology, Low-Speed Aircraft Technology (Rotorcraft), and High-Speed Aircraft Technology. Recognizing that Preauthorization Hearings were not held this past Fall to review progress, I will include remarks concerning some of the accomplishments and status of our program throughout my discussion, including a section dedicated to the Aircraft Energy Efficiency Program.

Disciplinary Research and Technology

Aerodynamics - The primary goal of the aerodynamics program is to improve the understanding of the fundamental fluid physics of flows over the full range of aeronautical applications. The major focus is on providing the analytical tools, the data base, and new concepts for improving aircraft and missile aerodynamic performance. Future directions and highlights of activities in major areas of the program will be discussed. These areas are computational fluid dynamics, the application of cryogenic wind tunnel technology, drag reduction, wake vortex alleviation, supersonic and hypersonic research, and natural laminar flow airfoils and stall/spin research for general aviation aircraft.

The field of computational fluid dynamics is advancing rapidly with the development of new techniques and capabilities which reduce computational time, and thereby, the costs of solving complex fluid flow problems as illustrated in Figure 6. Recent improvements in numerical algorithms for two-dimensional viscous flows, developed at Ames and Langley Research Centers, have reduced computing time by more than a factor of twenty, allowing completion of complex flow solutions in minutes rather than the hours it took before. New emphasis will be on extending numerical algorithms, geometric modeling, and grid generation techniques to three-dimensional viscous flows. An area of particular importance is the development and application of adaptive grid techniques

to flow fields which have embedded regions of rapidly changing flow parameters. These techniques will automatically tailor the grid size, providing a dense grid in flow regions with large gradients and less dense grids for regions with relatively small gradients. The resulting solutions will be more accurate and substantially more efficient in their use of computer time. In order to assess the relative merits of flow codes currently under development, NASA, in cooperation with the Navy and the Air Force, recently sponsored a national workshop to verify and rank the various codes in their ability to model turbulence. Specifically selected experiments provided the data base required for the evaluation. The results identified a number of specific problem areas which will be investigated in FY 1983.

Progress in computational fluid dynamics in all phases of aeronautical research, from basic fluid dynamics research to preliminary component design and final configuration optimization, is limited by the computational capability, or problem solving power, of current computers. Research in computer science continues to study the feasibility of advanced system architecture, high-speed electronics, and interactive graphics for a new generation of scientific computers. These computers will have sufficient computational power to solve such diverse problems as three-dimensional flow fields for complete aircraft, large-scale weather and climate modeling, and analysis of large, complex structures. A part of this continuing effort involves the Numerical Aerodynamic Simulator for which preliminary design studies were recently completed. Technical assessment of these studies continues and a detailed evaluation of the proposals for final design will commence in the near future.

Experimental facilities and techniques used to develop the data base for complex aerodynamic flows over aircraft and missiles are basic tools of the aerodynamics program. The NTF at Langley and the 80x120-foot modification to the 40x80-foot wind tunnel at Ames will become operational for research in FY 1983. These facilities are critical, not only to the experimental work, but also to the development and evaluation of computational techniques. Construction of the NTF is nearing completion. The overall facility building is shown in Figure 7 as is the control room and the test section. Operational verification of the facility and associated subsystems is in progress. The primary impetus for developing the NTF testing capability, as justified and coordinated through NASA/DOD agreement, was the discrepancy between wind tunnel and flight test results for transonic aircraft. A major reason for the discrepancy has been the deficiency in full-scale flight Reynolds number simulation in wind tunnel tests. In the first significant test, scheduled to start in the first quarter of FY 1983, the effect of Reynolds number on the performance of a transport aircraft configuration will be investigated.

Reduction or even elimination of flow field interference effects between wind tunnel walls and the test model at transonic speeds provides another important opportunity to improve ground-facility flight simulations. During the past year, substantial progress was made in demonstrating two noninterfering, or adaptive, wall concepts. Both the computer controlled, flexible wall system, under development at Langley, and the controlled flow-through wall system, being developed at Ames, were tested in small-scale wind tunnels. Results produced test model flow fields with significantly reduced wall interference effects. Continued emphasis will be placed on developing and optimizing these concepts for possible application to larger wind tunnels.

A major advancement in aerodynamic research was achieved this past year in the experimental study of surface devices to promote turbulent drag reduction. Low-speed wind tunnel tests of large eddy breakup devices at Langley in simple configurations have indicated it may be possible to reduce turbulent skin friction by as much as 20 percent. Since friction accounts for approximately one-half of the total drag of aircraft at cruise conditions, reductions of this magnitude would mean tremendous fuel savings. Figure 8 illustrates how these surface modifications alter a normal, highly-agitated turbulent boundary layer to one in which the large drag-producing eddies have been reduced. The eddy breakup devices would be applicable to fuselages on which the very high Reynolds number flow makes laminar flow control impractical. Validation testing of the devices will be performed in FY 1983 at higher Reynolds numbers on flat plates and airfoils. Other methods of treating the surface to alter the turbulent friction will also be explored.

The emphasis of research into alleviating the vortices produced by large aircraft and encountered by trailing aircraft flying in landing approach patterns has changed from flight testing to more fundamental wind tunnel and analytical investigations. A number of flight techniques and attenuation devices have been evaluated and some of the most promising, such as selective deployment of wing spoilers on transport aircraft, have been verified in flight. None of the approaches, however, have proved to be practical. New approaches are being used to understand the basic fluid mechanics of vortices in the wake of lift devices and to predict the resulting flow field. In Figure 9, the left photograph is a smoke visualization of an aircraft wake-vortex element showing a very strong core in the center of the vortex. This core has a large velocity component in the axial direction as the wind tunnel data show. It appears that the higher the core velocity, the longer the vortex persists. The key to understanding and thereby controlling trailing vortices is to be able to predict their formation and dissipation. Wind tunnel tests at Langley will be conducted to obtain detailed wake flow measurements to complement the existing NASA and Federal Aviation Administration (FAA) data base. The photograph in the figure shows the light paths generated by a high-speed laser velocimeter

system used to measure velocity profiles in the wake flow. A moving-base piloted simulator will also be used to develop acceptable limits of vortex disturbances for trailing aircraft. The FAA has identified NASA wake-vortex alleviation research as one of its highest priority needs. Alleviation of vortices will allow significant gains in airport capacity while still maintaining safe operations in the terminal airspace and on runways. Fundamental analytical and experimental studies of advanced swept-wing configurations for supersonic and hypersonic aircraft are underway, and will continue in FY 1983, to determine the effects of surface contouring and overall wing design on aircraft performance. As shown in Figure 10, the effort will include evaluation of advanced wing configurations, vortex flap concepts, and laminar flow drag reductions to increase range and maneuverability.

Improved methods for the design of natural laminar flow airfoils for application to general aviation aircraft have been experimentally validated in the Langley Low Turbulence Pressure Tunnel. These airfoils are designed to reduce drag by delaying boundary layer turbulent transition while achieving high lift for takeoff and landing as well as other desirable aerodynamic characteristics. For lift coefficients near unity, drag coefficient reductions up to 40 percent can be realized as indicated on the left side of Figure 11. For a full-scale aircraft having natural laminar flow wings, drag reductions of more than 10 percent appear feasible during cruise with attendant improvements in performance and fuel economy. Wind tunnel and full-scale flight tests of a variety of airfoils have demonstrated that the theoretically predicted extent of natural laminar flow can be closely approached on wing surfaces produced by modern manufacturing methods. Flight tests with a partial span wing glove having a modern natural laminar flow airfoil were used to develop instrumentation and flow measurement techniques, and as a means of investigating the sensitivity of boundary layer transition to surface defects, insect contamination and other environmental effects. During FY 1983, natural laminar flow research will pursue practical methods for overcoming adverse environmental effects, such as ice formation and insect contamination, and will study three-dimensional wing design requirements and limitations.

In the area of stall/spin research for general aviation aircraft, the segmented, drooped-wing leading-edge modification previously tested on low-wing aircraft with basic tail configurations, was found to be effective in reducing the abruptness and severity of aircraft stall and in preventing development of unrecoverable flat spin modes. A later adaptation to a low-wing T-tail aircraft configuration also proved to be effective in preventing aircraft autorotation. This type of stall/spin behavior modification is indicated in Figure 12. During FY 1982, the emphasis has shifted from the study of model and full-scale flight characteristics of different aircraft configurations to

development of analytical techniques for predicting aircraft stall/spin characteristics and establishing reliable design methods. In FY 1983, stall/spin research will concentrate on the development of these analytical prediction methods aided by the extensive experimental data base accumulated in past years.

Propulsion - The aeronautical propulsion research and technology program is a broad-based multidisciplinary effort directed at providing the knowledge and understanding which will lead to continued improvements in the performance, efficiency, reliability, and durability of military and civil aircraft engines as well as reduce their fuel consumption, environmental impact and operating costs. The program encompasses research in the areas of turbomachinery components and internal computational fluid dynamics; combustion and fuels; inlets and exhaust nozzles; engine system dynamics and controls; advanced bearings, gears and seals; noise reduction; supersonic combustion ramjets; and advanced general aviation propulsion.

Continued advances in technology for gas turbine engines require a more fundamental understanding of the complex internal flows and heat transfer associated with rotating turbomachinery. In recent years, Lewis has significantly increased its emphasis on internal computational fluid dynamics with efforts focused on developing analytical methods to predict the steady and unsteady flow and thermal response associated with the complex flow through rotating blade passages in fans, compressors, propellers and turbines. Research, conducted in cooperation with academia and industry, provides detailed experimental data to both understand the flow physics and verify that the fluid dynamics is properly modeled.

In FY 1981, development of a comprehensive computer code capable of modeling three-dimensional inviscid flows in compressor blade rows was completed. The ability to handle advanced compressor flow fields including strong shock structures represents a significant advance in internal computational fluid dynamics. As indicated in Figure 13, the computed flow field through a transonic compressor rotor operating at a near stall condition shows excellent agreement with nonintrusive Laser Doppler Velocimeter measurements. This new analytical capability will enable rapid assessment of new airfoil and endwall shapes, minimizing the need for costly experimental evaluation. This effort will ultimately lead to the design of tailored airfoils which control shock location, shock strength, and secondary flows for improved pressure ratio, efficiency and operating range.

In FY 1983, the computational capability at Lewis will be upgraded to support the continuing increase in emphasis on computational fluid dynamics research and, more specifically, the long-range capability for analysis of complex, three-dimensional viscous internal flows. Efforts will continue to develop faster computational methods, and to develop algorithms tailored to exploit the parallel processing capability

of state-of-the-art high-speed computers. Detailed flow and heat transfer investigations in blade cascades, large low-speed rigs, and advanced high-speed stages will continue with emphasis on boundary layer behavior, secondary flows, turbulence structure, and rotational effects for modeling and code verification.

Included in the effort to improve the fundamental understanding of internal flow is research on inlets, ducts, and exhaust nozzles with current emphasis on high-speed inlet aerodynamics for supersonic cruise aircraft (Figure 14). Today's supersonic inlets are designed for short duration at supersonic flight Mach numbers and thus are relatively inefficient for supersonic cruise. Lewis has developed a novel approach to analytically describe the flow field, which takes advantage of the naturally occurring flow regions made up of the supersonic inlet, the terminal shock, and the subsonic diffuser. The analysis codes currently under development for each region will be integrated into a comprehensive design and optimization technique which accurately accounts for the viscous, three-dimensional flows occurring in high-speed inlets. The codes for the supersonic inlet and subsonic diffuser regions are essentially complete and initial benchmark verification experiments, including glancing sidewall shocks for the inlet region and secondary flows in diffusers, have begun. In FY 1983, the terminal shock region code will be completed and full configuration verification experiments using realistic inlets will be performed to determine accuracy of the codes at angle-of-attack.

Fuels research at Lewis is centered on developing a fundamental data base relating chemistry, physical properties, and effects of current aviation fuels as well as potential future fuels derived from heavy, poorer quality petroleum crudes and syncrudes. As indicated in Figure 15, program emphasis is on establishing a detailed understanding of the relationship of chemical composition and molecular structure to physical characteristics such as thermal stability, viscosity and freeze point, and ultimately to engine effects in terms of combustion, emissions, component performance and durability. In response to the additional funding appropriated by Congress in FY 1981, Lewis expanded its efforts to develop a broadbase capability in unique facilities and technical expertise for preparation, analysis and characterization of aviation fuels. Research activities in FY 1981 focused on the study of thermal stability which is a measure of a fuel's tendency to decompose during long-term storage or when exposed to high temperature surfaces. It was found that the rate of deposit formation was not only a function of total nitrogen content but was also strongly dependent upon the specific chemical structure and type of nitrogen compounds present. In FY 1983, research to expand the data base will continue with emphasis on developing advanced fuel analysis techniques, improved understanding and control of specific instability reaction mechanisms and rates, and exploring the behavior of fuels at or near their freezing point.

Combustion research has made considerable progress in recent years in the understanding and modeling of combustion processes typical in gas turbine engines. As indicated in Figure 16, FY 1981 research focused on analytical modeling and experimental evaluations of simple combustion flow fields. Emphasis was placed on the unsteady, large-scale turbulent flow phenomena representative of gas turbine combustion systems. Current models were compared to flow field and turbulence intensity data obtained using a two-color Laser Doppler Velocimetry technique. These comparisons indicate a critical need for improved combustor flow field models and provide a basis and direction for modeling research in FY 1983. In addition to these efforts focused on large gas turbines, basic combustion research applicable to small engine combustors for rotorcraft engines is being pursued jointly with the Army. Additional emphasis will be placed on this important class of engines in the coming year.

As engine overall pressure ratio has increased to improve performance, nonrecoverable stall has become a significant problem causing aborted missions and, in some cases, the loss of aircraft, particularly with high-performance military aircraft engines requiring afterburner thrust augmentation. A nonrecoverable stall occurs when a compressor surge or stall causes an engine to depart from its normal operating mode, shown in Figure 17, and enter an unstable, reverse-flow cycle that often requires shutting down and restarting the engine in flight. In FY 1981, a comprehensive program to better understand engine stall was initiated as part of a cooperative program with the Air Force. NASA is exploring causes of engine stall and its recovery through engine systems analysis, control-mode changes, compressor component research, and high-bypass-ratio engine systems research while the Air Force is concentrating on analysis and experimentation of low-bypass-ratio engines to eliminate operational problems. Currently, the system dynamic modeling is underway. It is providing preliminary results to guide the systems interaction testing of a TF34 high-bypass-ratio engine during FY 1982. In FY 1983, the systems dynamic analysis will be extended to include both stall avoidance and stall recovery models, compressor design criteria, and benchmark performance data that will lead to future engines being able to perform over a wider operating range than is possible today.

For more than a decade, NASA played a principal national role in developing the basic prediction tools and the advanced technology aimed at reducing the noise of jet-powered transport and general aviation aircraft. While this problem is still a major concern, the capability represented by the industry is now strong and mature, and the emphasis in the NASA program can now be turned to new challenges. Community and interior noise are serious problems for rotorcraft while community and passenger acceptability are potentially major barriers to future advanced turboprop-driven aircraft. By redirecting its noise reduction research, NASA is placing increased emphasis on understanding the noise generating processes

and predicting the aeroacoustic characteristics of high-speed propellers and rotors (Figure 18). Predicting noise generated by high-speed rotating blades involves a complex interaction of a number of noise sources influenced by blade loading and thickness, rotating speed, ambient air conditions, forward velocity, and unsteady pressure distributions due to the detailed wake flow field produced by preceding blades. During FY 1981, initial aerodynamic and acoustic measurements on high-speed propeller configurations were made in the Lewis 8x6-foot wind tunnel. Correlation of both wind tunnel and flight data with predicted noise levels, shown in Figure 18, indicates that the greatest discrepancies between theory and experiment occur in the transonic Mach number range. In 1983, the aeroacoustic data base for propellers and helicopter rotors will continue to be expanded through tests in the 8x6-foot wind tunnel and in the V/STOL wind tunnel at Langley. Analytical research will focus on improved modeling of the unsteady aerodynamics using advanced computational methods and the development of validated near- and far-field noise prediction methods which take into account nonlinear terms and transonic compressibility effects.

The hypersonic propulsion effort, illustrated in Figure 19, is aimed at developing an understanding of the fundamental processes of mixing and combustion in supersonic flows in the Mach 4 to 7 range. Fundamental research and component investigations are being conducted at Langley on inlets, combustors, and nozzles for supersonic combustion ramjet (SCRAMJET) concepts. This technology is applicable to propulsion systems for either cruise aircraft, air-breathing space launch vehicles, or high-speed, highly maneuverable missiles. In FY 1981, analytical modeling accomplishments allowed a complete two-dimensional flow calculation through the engine that provides a basis for the prediction and control of inlet/combustor coupling effects. Significant progress was made in the area of nonintrusive combustion diagnostics with the development of an ultra-violet absorption technique for temperature measurements and a Coherent Anti-Stokes Raman Spectroscopy system for measurement of temperature and species concentrations. Component research successfully demonstrated subsonic/supersonic combustion mode performance, and excellent internal engine performance was achieved for the first generation hydrogen-fueled SCRAMJET module at Mach numbers of 4 and 7. The goal of the program in FY 1983 will be to demonstrate, through ground tests of a single subscale engine module, improved net thrust levels at these Mach numbers. These tests would constitute "proof-of-concept" for SCRAMJET technology.

Propulsion research for general aviation aircraft is focused on providing the technology base for advanced intermittent internal combustion engines with jet fuel and multifuel capability, reduced fuel consumption, reduced weight and emissions. The two most promising advanced engine concepts are a high-speed, liquid-cooled rotary

combustion engine and a two-stroke stratified charge piston engine as illustrated in Figure 20. For these engine concepts to be useful in commercial applications, several areas of advanced technologies must be investigated. The development and validation of combustion modeling and diagnostics will provide an understanding of processes that control engine efficiency, emissions and fuel requirements. Rotary apex seal materials research, fuel injection and stratified charge combustion studies, engine cooling technology, and high efficiency turbocharger technologies will also be addressed in FY 1983. Engine and component testing is conducted in facilities at both Lewis and in the industry. Universities, supported by NASA grants, are involved in combustion modeling and research of advanced component technologies. Curtiss-Wright, a prime industry contractor for the rotary engine, has demonstrated a reduction in fuel consumption from .44 lb/hp-hr to .39 lb/hp-hr relative to the program goal of .35 lb/hp-hr. Also, Teledyne-General Products Division is testing an advanced single cylinder stratified charge piston engine to determine its performance map and define the requirements for a high performance fuel-injection system. Such a system will aid in achieving the goal of 90 hp per cylinder in this type of engine sized for general aviation.

In addition to the engine technology just described, low-speed propeller research encompassing analytical and experimental studies on advanced general aviation propeller performance, acoustics, aeroelastic characteristics, and low cost composite materials will continue. A broad spectrum of propeller sizes, power requirements, and aircraft speeds applicable to current and future general aviation aircraft are being investigated.

Materials and Structures - In FY 1983, materials and structures research will maintain its strong emphasis on advanced structural and materials concepts, on the development of efficient computational methods for structural analysis and design, and on improved experimental techniques for future airframe and engine systems. Recent research to increase performance, energy efficiency, and flight safety continues to provide high payoff to both military and commercial aircraft systems.

One area of research on the aeroelastic behavior of aircraft structures involves the study of flutter, e.g., the dynamic coupling between the aerodynamic forces, the structure, and external weapon systems stored beneath the wing of modern high-performance fighter aircraft. Some configurations for external weapon stores can increase an aircraft's susceptibility to flutter and thereby limit its combat mission effectiveness. As part of a cooperative program with the Air Force, NASA research on passive flutter control of wing/store configurations complements the ongoing Air Force/NASA research program directed at active control technology for flutter suppression. A Langley concept for passive flutter suppression, shown in Figure 21, has been verified by tests

in the Transonic Dynamics Tunnel. This concept, known as the Decoupler Pylon, dynamically isolates the wing from the weapon store in pitch motion by means of a spring/damper control system. Wind tunnel tests have demonstrated at least a 40 percent increase in flutter onset speed when compared to a standard rigid pylon. Analytical and experimental feasibility studies have been successfully completed. Flight hardware will be built over the next two years, and a flight evaluation program using an F-16 is planned for FY 1984.

High performance is a critical military system requirement. Today's advanced fighter aircraft have large components built from composites to reduce weight relative to comparable metal construction. Lighter weight contributes to the greater speed and maneuverability required in combat. As the utilization of composites increases, knowledge and confidence to use them in larger, more heavily loaded structures of both military and civil transport aircraft also increases. Current composite materials are composed of an epoxy matrix reinforced with graphite fibers. Unfortunately, current epoxy matrices lack toughness, are sensitive to moisture, and have variable properties. Present design practices allow for these limitations, but the allowance tends to reduce the weight-saving potential for heavily loaded applications. NASA has embarked on an extensive effort to improve matrix resin materials. The principal objectives of the work are to provide tougher, more easily processible composites that are environmentally durable. As illustrated in Figure 22, recent experimental advanced resins have been found that could lead to much tougher composites able to withstand greater strain and impact loading. The additional weight saving to be realized by composites incorporating these new resins for large structures, such as large transport wings, is portrayed. During FY 1983, research will concentrate on the durability and damage tolerance of these tough polymer resins.

In recent years, optimizing the design of high-performance military and commercial transports has become increasingly more difficult. As vehicles become more complex and mission requirements more demanding, the requirement for more detailed structural analysis has led to significant escalation in the cost and time for performing structural calculations. While developments in minicomputers and interactive graphics have provided some alleviation of the problem, recent advances in microprocessor technology show even greater potential for improved computational efficiency through special purpose computers tailored to structural needs. Langley has developed a proof-of-concept microprocessor capable of performing finite-element structural analysis at computational speeds 10 times faster than currently possible. Figure 23 illustrates the concept. The equations describing the structural model are transferred into the microprocessor array by assigning various parts of a structure to individual processor chips. A major FY 1981 accomplishment has been the successful implementation of a 16-processor configuration which was utilized to solve several small

structural problems. Calculations were carried out in parallel rather than by conventional sequential solution approaches. In FY 1983, computer hardware options, including the type and organization of 36 individual processors, will be investigated and numerical solution algorithms will be developed.

Complementary to the high-performance, lightweight airframe research effort is a major thrust in gas turbine engine materials and structures. The requirements for greater performance and lower specific fuel consumption result in higher engine operating temperature. Steady progress has been made over the years to increase the ability of materials to function in this highly demanding environment. However, the combination of high metal temperature and the aggressive oxidative and corrosive atmosphere have severely limited turbine airfoil life. One approach to increasing metal operating temperature capability without sacrificing component life has been the application of methods for strengthening existing alloys as illustrated in Figure 24. Laboratory and engine tests at Lewis have shown that the dispersion of fine, high-melting point ceramic oxide particles throughout the alloy, thus referred to as oxide dispersion strengthened or ODS alloys, extends the allowable operating temperature without loss of strength. It is anticipated that this ODS material will be available for the next generation of high-performance military and civil turbine engines for blade, vane, and combustor liner applications.

A concept which permits even higher temperature is the application of advanced metal matrix composites for turbine blades, also shown in Figure 24. By embedding strong, high-temperature tungsten fibers in an extremely oxidation-resistant superalloy, it is possible to achieve operating temperatures in excess of 100°C above current alloys. Lewis has successfully achieved a laboratory-scale fabrication process for producing turbine blade airfoils with imbedded tungsten fibers. More than a dozen refractory alloys were considered before tungsten was chosen as a suitable fiber. Work will continue on these high-temperature engine composites during FY 1983, exploring designs to best utilize the unique composite properties and to improve processibility.

The efforts on high-temperature engine materials have been redirected over the past few years to conduct critical research aimed at conserving the Nation's strategic materials. The United States is not self-sufficient in certain strategic metals required for gas turbine engine components. It is necessary to import virtually all cobalt, columbium, tantalum and chromium needed for today's superalloys. These metals provide high-temperature strength and oxidation/corrosion resistance in both military and commercial engines. In FY 1981, Congress recognized the significance of the problem and increased NASA funding to begin research on methods to reduce the vulnerability of the country in this area. As shown in Figure 25, Lewis

has made steady progress over the past year in understanding the role of cobalt in complex superalloys. Research on cobalt's effect on microstructure and design properties will offer the opportunity to reduce cobalt content without sacrificing properties or, alternately, suggest the addition of other substances in place of cobalt. It has been shown that a 50-percent reduction in the quantity of cobalt does not reduce high-temperature strength. This aspect of the effort, which will be expanded to include other properties and other strategic alloys during FY 1983, is supplemented with a research activity to develop new classes of materials containing no strategic elements at all. Nickel aluminide intermetallics, although currently too brittle for engine applications, are one such material. Research in FY 1983 will be directed at methods to increase the ductility of this potentially superior material.

The flight safety aspect of the materials and structures research program is concerned with problems relating to both general aviation and large, commercial transports. Modern commercial aircraft require the maximum safety compatible with good economics and minimum operational constraints. A joint NASA/FAA general aviation aircraft crashdynamics research effort, depicted in Figure 26, is directed at providing the necessary structural design technology to increase passenger survivability in the event of a crash. Energy-absorbing, load-limiting aircraft seats, restraint systems, and fuselage subfloor designs have been developed along with improved static and dynamic testing and analytical predictive methods. Representative fuselage floor crash acceleration pulses have been identified from general aviation full-scale crash tests, and a data base has been established for the definition of fuselage floor pulses for use in dynamic seat testing. The FAA needs this type of data to define seat test methods. The capability of the NASA computer program to model behavior during an airplane crash of load-limiting general aviation seats and fuselage subfloors was demonstrated. These computer programs will be released to industry during a workshop in FY 1982. Also, during FY 1982, dynamic testing of load-limiting general aviation aircraft seats and fuselage structures will proceed with emphasis on unique subfloor concepts embodying the best features of previous research. A contract study of composite structural design and fabrication techniques best suited for light aircraft use was also begun to help provide a basis for planning focused research in this area. In FY 1983, research in structures will continue the evaluation of design methodology for optimal crash load-limiting structures for general aviation, extending this effort into the realm of composite materials. Focused research in composites for light aircraft will be initiated based on previous study determinations.

Building upon the success and knowledge gained from the general aviation research program, the activity has been extended to include crash dynamic analysis of transport type aircraft. A joint NASA/FAA study has been completed characterizing transport crash scenarios. Discussions are

now underway with the FAA to plan a coordinated research program leading to a fully instrumented transport crash test to provide data on dynamic response and Anti-Misting Kerosene (AMK) safety fuels.

Another aspect of the ongoing transport crashdynamics effort is research on increased survivability in a post-crash fire. This activity at Ames, described in Figure 27, is presently developing a survivability model for flammable materials, including such parameters as combustion reactions and exit time. Accompanying this study is research on lightweight, more fire resistant, graphite composite aircraft interiors to replace current fiberglass material. In the past year, a range of new fireworthy materials, including seat cushions, floor panels, sidewalls and windows, have been developed and evaluated by Ames and the Johnson Space Center. This cooperative NASA/FAA research activity includes actual full-scale testing in the FAA aircraft simulator, which provides data necessary for future material selections. This work will continue in FY 1983 with emphasis on relating laboratory test methodology to full-scale tests and improved modeling for flame spread. Ames and the Jet Propulsion Laboratory are also supporting the FAA in evaluating AMK safety fuels to eliminate flame spread through the fuel mist to pools of spilled jet fuel. Lewis has completed research for the FAA on jet engine modifications required to use AMK fuels.

Controls and Guidance - The broad objectives of the controls and guidance research and technology program are to develop a fundamental knowledge base for the application of control theories and fault-tolerant computers to aeronautics and for the characterization of environmental effects on flight safety. The major thrusts of the program are applied control theory, flight-crucial controls technology, flight guidance, and environmental effects research.

The NASA program in flight-crucial controls is developing a solid foundation of analytical tools and advanced concepts for the design and verification of electronic controls that will allow new aircraft design possibilities. Research on fault-tolerant controls at Langley will be expanded in FY 1983 as the new Avionics Integration Research Laboratory (AIRLAB) becomes operational. The desirable feature of a fault-tolerant system is that it continues to function at full performance even with multiple failures in elements of the hardware or software. Fault tolerance is necessary to achieve the extremely high degree of reliability needed to implement crucial flight functions. The AIRLAB Facility, illustrated in Figure 28, will be the most advanced laboratory in the country devoted to research on fault-tolerant electronic controls. NASA is bringing together an informal consortium of universities, industrial research organizations, and in-house expertise to guide the direction of the research and to develop the new concepts that will be investigated in AIRLAB. The first two fault-tolerant computer concepts for flight applications ever developed in the United States were developed for NASA under contract

to Rockwell International Collins Division, Charles Stark Draper Laboratory, Bendix and Stanford Research Institute. These experimental units will be tested and analyzed in AIRLAB starting in FY 1983. The knowledge gained from this research will lead to new distributed architectural concepts that can be expanded to entire electronic control systems. The other two key elements of this research are fault-tolerant software and analytical techniques. The concept of devising fault-tolerant software is quite new and several exploratory approaches must be pursued because it is virtually impossible to detect all possible software faults. Fault-tolerant software would provide alternate logic paths within the software if an error is detected, avoiding the need for redundant back-up systems in digital flight control.

Figure 29 depicts the major elements of the flight path guidance activities in FY 1983. This thrust provides advanced technology to improve the efficiency and safety of flight in the evolving National Airspace System, including optimal guidance algorithms, traffic flow management concepts, operational procedures and crew interface concepts. An important and practical guidance algorithm, developed at Ames, allows aircraft to fly optimal flight paths from takeoff to landing that will minimize fuel and time-of-flight taking into account air traffic control restrictions and weather. Much of industry is now using optimal flight path concepts. In FY 1983, the algorithm will be further developed to meet specific time and arrival constraints and it will also be expanded to conduct traffic flow management research with the FAA to increase traffic flow capacity. A major FY 1983 emphasis will be in the technology base for a highly automated crew flight station. A simulator to explore advanced concepts as illustrated in Figure 29 will be developed at Langley.

Research activities in environmental effects on flight safety includes research on the effects of lightning, turbulence, wind shear and icing. Research in meteorology hazards to aviation will continue using two flight research aircraft to characterize severe storms and the effects of lightning and turbulence on future aircraft systems design and operations. Figure 30 shows a key element of the research effort addressing the effects of lightning on digital flight systems. The induced electrical and magnetic effects of direct lightning strikes have been measured in flight using a specially instrumented research aircraft at Langley. These data will be used by NASA and DOD in FY 1983 to develop mathematical models of lightning-induced errors in digital systems and as input test signals in laboratory experiments to characterize the effect on aircraft components such as fault-tolerant computers and nonmetallic aircraft structures. The FAA is also participating in this research and will use the data in future aircraft systems qualification.

Finally, icing research in the unique Icing Research Wind Tunnel at Lewis will be directed in FY 1983 toward the development and evaluation of improved icing sensors, instrumentation, scaling laws, and the study of modern airfoils under icing conditions. Improvements in wind tunnel productivity for icing experiments are planned using improved aerodynamic measurement devices and more representative icing conditions. Lewis is also developing a flight research program to correlate the wind tunnel research. Interagency agreements on icing research were developed between NASA, the Air Force and the FAA.

Human Factors - The goal of the human factors program is to develop a fundamental understanding of aircrew capabilities, limitations, and tendencies in order to provide the technology base for solving human problems impeding the growth, safety and efficiency of air transportation. The program encompasses flight management, simulation technology, workload and performance measurement, and human response to noise.

Flight management research focuses on developing innovative concepts in crew-cockpit design technology which can improve aircrew performance in making and affecting decisions. Research in flight management includes the development of advanced display capabilities such as Cockpit Display of Traffic Information (CDTI). This effort, which is jointly sponsored and conducted with the FAA, has developed a generic display format, shown in Figure 31, and has performed preliminary simulator evaluations of pilot ability to use a CDTI to perform maneuvers such as spacing and merging, which could otherwise be done only by an air traffic controller. If further testing, using full-mission simulation and actual flight, confirm these findings and indicate no unexpected safety problems, CDTI may provide significant workload reductions in the control of air traffic. In addition to such evaluations, the CDTI research in FY 1983 will focus on the interaction of a CDTI and a collision avoidance system. The FAA has stated that the Threat Alert and Collision Avoidance System (TCAS) will be ready for General Aviation (TCAS II) in 1985. The joint NASA/FAA effort will investigate the compatibility of pilot reactions to CDTI and to TCAS, possible effects of CDTI reducing the TCAS alarm rate, and possible effects of CDTI on the acceptability of a TCAS false alarm rate.

While aviation continues to be the safest mode of transporation, this record can only be upheld through constant vigilance. The purpose of the Aviation Safety Reporting System (ASRS), which NASA manages for the FAA, is to identify deficiencies and discrepancies in the national aviation system and to provide a comprehensive data base for human factors research. The ASRS data base, presently numbering over 30,000 reports, was heavily used by the Presidential Commission on Crew Complement and by the FAA, the National Transportation Safety Board (NTSB), the Flight Safety Foundation, and Congress during investigations of the air traffic controllers strike. In addition, the

ASRS has served as motivator and data source for Federal Aviation Regulations on nonessential cockpit duties (FAR part 121, 135) and on sky diving (FAR part 105), and has led to alteration of the Air Force low-level flight rules.

NASA is also investigating the effects of circadian desynchronosis on pilot ability to collect, process and transfer information. This activity which will study both military and civilian crews, is being conducted jointly with the Air Force and the Army. Initial data, shown in Figure 32, from the ongoing field study show the effects of a trip sequence on two individuals' sleep/wake cycles. The purpose of the field study is to determine the significance of the effects of fatigue and desynchronosis on actual performance. The next step is to develop and validate methods of minimizing those effects.

The major research tool in aeronautical human factors is simulation. An important part of NASA's human factors program is devoted to developing advanced simulation techniques and research methods. This activity includes development of improved visual cue presentation methods, such as the generation of simulated fog effects, improved methods of interfacing visual and motion systems so that potentially conflicting cues are eliminated, and improved techniques for assessing the degree of simulation necessary for empirical validity. A portion of this simulation research is in support of the FAA. NASA has developed, in close cooperation with the FAA and the airlines, guidelines for the development of Line Oriented Flight Training (LOFT) programs, that is, aircrew training programs incorporating high-fidelity, full-crew, full-mission simulations. These guidelines were incorporated in the FAA's September 1981 Advisory Circular on LOFT. Further work in this area will focus on advanced methods for presenting abnormal (malfunctions and emergency) operations.

The Man-Vehicle Systems Research Facility (MVSRF) at Ames, pictured in Figure 33, will be ready for operation in FY 1983. This new facility will constitute the most sophisticated tool for aviation human factors research in the country. The MVRSF will be comprised of two aircraft simulators which can be flown individually or simultaneously, an air traffic control station, and the capability to generate other traffic either by programming or by use of pilots who will manipulate simple control boxes. The latter method allows the simulated traffic to respond interactively to the pilot's actions in real time. This capability will prove to be invaluable in programs such as CDTI, circadian desynchronosis, and the human factors of cockpit automation.

Any aviation research involving interaction with the air traffic control system must have the interactive traffic capability in order to achieve an acceptable level of experimental validity. Presently, such traffic can be generated only through the use of pilots with a simple control device. To develop an improved understanding of pilot

behavior, as well as to increase experimental flexibility and reduce research cost, NASA has been developing computer models of the pilot/aircraft system which could be used to generate the other interactive traffic. In the past year, a model of a pilot flying a CDTI-equipped aircraft in an airport traffic area was developed and validated (Figure 34). While it will be very useful in CDTI research, the model is limited in output to the aircraft flight profile. The FY 1983 focus of this research is the development of a model of the entire flight crew, which incorporates all of their information sources, cognitive processing, and behavioral outputs such as monitoring, discrete and continuous contact, and communications.

NASA's human factors research includes efforts to develop improved man-machine interface technology for reducing the workload of single pilots under instrument flight rules. Recent accomplishments include flight demonstration of a three-dimensional computer-generated cockpit display that facilitates enroute and terminal-area navigation. This concept, called the "follow-me box," provides a target for the pilot to follow which is analogous to in-trail following under visual flight conditions. Also during FY 1981, a successful demonstration using simulation was completed for the Automated Terminal Approach System (ATAS). ATAS is a method of automating pilot functions during instrument approaches, missed approaches, and holding patterns. During FY 1983, flight tests will be conducted of a refined ATAS, and investigations will be made of the feasibility of using voice synthesis and recognition technology for reducing single pilot workload under instrument flight conditions.

Frequent requests for use of NASA's aeronautical human factors expertise and facilities are made by civilian and military organizations. In addition to the research described above in support of the FAA, the Air Force, the Army, the NTSB and the Presidential Commission on Crew Complement, NASA provided significant support to the Navy, NATO-AGARD, the National Academy of Sciences, the DOD and the National Institute of Health.

Low-Speed Aircraft Technology

The Low-Speed Aircraft Technology program is devoted primarily to R&T Base and Systems Technology efforts related to rotorcraft. A single Short Takeoff and Landing (STOL) Aircraft Systems Technology activity is also included which involves the Quiet Short-Haul Research Aircraft. The majority of the rotorcraft technology activity is conducted in close cooperation with the Army Aviation Research and Development Command through three Army Research and Technology Laboratories co-located at Ames, Langley and Lewis. Some segments of the Low-Speed Aircraft program are also conducted in cooperation with the Navy and the Defense Advanced Research Projects Agency (DARPA) in support of military technology needs. Similar coordination takes place between NASA and the FAA in selected areas of rotorcraft and STOL research related to civil missions.

The objectives of the Low-Speed Aircraft R&T Base program are to provide a technology base in rotorcraft structures and dynamics, aerodynamics, acoustics, flight dynamics and control, man-system integration, and wind tunnel and flight experiments support. The objective of the Systems Technology program is to provide ground-based and flight research on integrated systems which hold long-term promise as viable military and civil rotorcraft and STOL concepts. The program covers the broad technology areas of configuration aerodynamics; propulsion; integrated flight systems including controls and guidance; and structural systems including advanced materials applications, vibration reduction, noise reduction and performance improvement. The experimental ground-based and flight testing is closely coupled with the co-located Army Laboratories and complements the NASA and Army R&T Base activities.

During FY 1981, meetings were held with two groups of the civil transportation community in order to gain a better understanding of rotorcraft technology needs and opportunities. A major conference was held with the American Planning Association to exchange information with transportation planners on technology issues related to rotorcraft and commuter aviation opportunities. A workshop was also held with representatives of the Emergency Medical Service community to define their needs and the potential benefits offered by future rotorcraft technology.

Noise is a top priority with the helicopter industry and with local communities. The concern over noise is reflected in proposed noise standards now being formulated by the International Civil Aviation Organization. The FAA is also addressing the issue of helicopter noise, and some local communities are meeting the proposed introduction of helicopter operations with local rulings on allowable noise levels. NASA is focusing increased attention in the area of helicopter noise with the goal of developing the technology necessary for the accurate

prediction of the noise characteristics of new helicopter designs. The ability to accurately predict rotorcraft noise is a technology challenge that, if not met successfully, can result in a prohibitive economic burden on the United States helicopter industry. Research plans have been formulated that involve a coordinated effort between Ames, Langley and Lewis as well as with industry, the Army and the FAA.

The feasibility of reducing noise while maintaining rotor performance was demonstrated in a series of successful helicopter model tests in the Langley 4x7-meter wind tunnel. In addition, an initial flight test effort, shown in Figure 35, was completed utilizing the YO-3A aircraft to obtain in-flight noise data on a highly instrumented AH-1G helicopter. This aeroacoustics flight research provided simultaneous data on radiated noise and rotor airloads, which will now form the basis for developing analytical prediction methods. Flight research will continue utilizing the YO-3A aircraft to survey the external noise of other helicopters. Discussions will also continue to strengthen the integration of NASA and industry noise research activities.

There is a substantial effort underway in rotor research. A number of advanced concepts are being explored, including passive means of enhancing performance and reducing vibration by the use of tailored rotor blade aeroelastic characteristics. In a joint Army/NASA effort, the feasibility of such techniques was successfully demonstrated in dynamic model tests in the Langley 16-foot Transonic Dynamics Tunnel, shown in Figure 36. A sophisticated rotor blade concept and advanced materials were utilized to design blades with nonuniform stiffness and planform shape and with swept, tapered and drooped tips. These unconventional aeroelastic features incorporated in the model rotor have shown the feasibility of the concept and have provided the data for the design of future tests. A series of rotor model tests is planned with systematic variation of tip geometry for establishing a more extensive data base and allowing correlation with analytical predictions.

An important element of long-term research on rotor systems is the availability of the unique research capability embodied in the two Rotor Systems Research Aircraft (RSRA) now in operational status. The goal of the joint NASA/Army RSRA activity is to make the two extensively instrumented flight test aircraft available over an extended period as prime research aircraft for rotor flight testing and extensive flight investigations of rotorcraft aerodynamics, structural dynamics, flight dynamics and control, and handling qualities. The helicopter configuration, illustrated in Figure 37, is now in flight research status following detailed calibration of onboard instrumentation and load-measurement systems. Experimental programs on rotor/fuselage

aerodynamics and stability and control are now underway. The second aircraft, in the compound configuration which results from adding a wing and auxiliary thrust engines to the helicopter, is also in flight status. Calibration of this aircraft and initiation of an extensive flight-test program are planned to establish a detailed comprehensive data base utilizing the S-61 rotor system. Efforts to improve the load-measurement systems will include dynamic loads in addition to the current static load capability. A joint NASA/Army activity will be initiated to acquire a modern four-bladed rotor and an advanced research rotor for follow-on testing to extend the rotor data base and to verify currently available analytical methods.

Recently, the Army and NASA joined in a cooperative effort to investigate the potential for making major improvements in rotors for current production Army aircraft including the UH-1, AH-64, and UH-60 helicopters. The initial effort (Figure 38) explored new rotor blade configurations that offered increased performance capability. Testing of promising rotor configurations was conducted in the Langley 4x7-meter wind tunnel. Product improvement options are now available because advances in rotor technology are made on a continuing basis. New airfoils, new materials, advances in analytical methods, and a growing data base have become available since the rotors of the current inventory helicopters were designed. The wind tunnel model investigations verify that 10-percent reductions in hover power and 19-percent reductions in required forward flight power can be achieved with a simultaneous reduction in rotor noise. Additional testing is planned with alternative blade configurations to establish a solid data base on performance and noise.

A joint NASA/Army Tilt Rotor Research Aircraft activity (Figure 39) involves two research aircraft, which are currently undergoing a series of flight tests which will verify the tilt rotor technology through proof-of-concept testing, detailed flight envelope documentation, and mission suitability testing. The joint effort was initiated in the early 1970's, and the two aircraft are now operational. One aircraft participated in the 1981 Paris Air Show and demonstrated, with considerable success, the unique capabilities inherent in the tilt rotor concept. The initial flight research investigations have been completed in the areas of performance, downwash, noise and handling qualities. The flight envelope is being carefully documented, and speeds up to 300 knots have been achieved at altitudes to 21,000 feet. One aircraft has been returned to Bell Helicopter Textron for systems upgrading and a series of flight demonstration activities. Future activities will include continuation of flight envelope documentation at alternate weight conditions and extended flight demonstrations in support of the Army, Navy, Marines and Air Force.

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One of the priority needs identified in 1978 by a government/industry rotorcraft task force was the development of a modern analytical prediction of the dynamic response of helicopter airframes that would be available early in the design process. A research effort was initiated in 1980 to extend the NASTRAN static analysis method to the prediction of airframe dynamic response. The effort has progressed through the detailed planning using the CH-47 airframe, shown in Figure 40, as the modeling subject. An industry-wide critique of the extensive planning document has been completed to assure that design procedures compatible with all of the United States helicopter manufacturers are being incorporated. The modeling approach has been established and a test plan for validating the analytical methods is being developed. Detailed modeling guidelines have been established, and the cost impact to include dynamic analyses in the early design phase has been established and appears to be a rather modest fraction of the total design effort (approximately one percent). The research will continue in FY 1983 with validation tests of the CH-47 airframe via ground-based vibration tests. This will be followed by complete correlation of the dynamic NASTRAN prediction and the test data and subsequent publication of the dynamic NASTRAN program and guidelines.

Analysis and test correlation efforts are in progress on the development of improved design analysis techniques for spiral bevel gears used in large helicopter transmissions, illustrated in Figure 41. An improved spiral bevel gear analytical technique needs to be made available to the helicopter industry. Semi-empirical methods commonly available in the past were found to be inadequate when gear size was scaled upward. An expanded effort in large gear technology is now underway. The Army made the aft transmission hardware of the XCH-62 Heavy Lift Helicopter available for use in the NASA-sponsored effort. A finite-element analysis computer program has been formulated and checkouts have begun. Aft transmission static and dynamic strain surveys are completed, and a 50-hour endurance test at Lewis is underway. Follow-on activity in FY 1983 will include completion of the finite-element analysis calculations for gear stress prediction and correlation of predicted and measured stresses.

The goal of the joint DARPA/NASA effort on convertible engine technology for rotorcraft propulsion (Figure 42) is to provide the engine and control technology base for the design of advanced propulsion systems for high-speed rotorcraft and V/STOL concepts requiring a combined fan/shaft propulsion system. Such vehicles as the X-wing, Advancing Blade Concept, Folding Tilt Rotor, and fan-jet V/STOL are potential applications of convertible propulsion systems. The research effort includes concept studies to look at the engine cycle trades for various applications. A contracted effort is underway with General Electric to modify a TF-34 fan engine to a

fan/shaft configuration. This modified engine and a breadboard control system will be delivered in FY 1983 to Lewis for a ground-test program. [25]

Steady-state testing will be followed by transient testing to explore the dynamic control requirements to allow rapid transfer from the fan propulsion mode to the shaft drive mode, as would be needed in transitioning from high-speed flight to low-speed and hover flight where rotor operation is the prime propulsion mode.

A portion of the flight research efforts of the Low-Speed Aircraft program is carried out at Ames in close cooperation with the FAA and complements rotorcraft engineering and development activities within that agency. The emphasis of the NASA activity is on remote site all-weather operations, illustrated in Figure 43. The objective is to provide single pilot operation capability to operate into and out of remote sites offshore and onshore with onboard guidance and navigation systems. Flight research activity has focused on the use of onboard weather/mapping radar modified as an "autotracker" for overwater approaches to offshore oil rigs. The testing explored the use of the airborne radar as a landing guidance system in conjunction with simple beacons and with passive reflectors at the landing sites. The potential of such techniques has been successfully demonstrated to the extent that airborne radar systems with higher resolution will also be investigated. In addition, an investigation will continue to evaluate the use of the differential Global Positioning System (GPS) for accurate guidance to remote sites. This scheme incorporates a simple ground-based reference for providing local corrections to the civil GPS data to allow all-weather approaches to small landing sites.

High-Speed Aircraft Technology

The High-Speed Aircraft Technology program consists of both R&T Base and Systems Technology efforts. Its primary objectives are to evolve and explore advanced technology concepts applicable to future high performance military airplanes and missiles, and to generate improved analytical prediction methods and experimental data for these promising concepts. On this basis, the DOD and industry can develop better future weapons systems in a timely and effective manner. Many of the activities are cooperative programs with industry and with DOD agencies such as the DARPA, Air Force, and Navy, and utilize the unique national facilities and expertise developed over many years by NASA. The research and technology efforts address a variety of high-speed military vehicles, including advanced tactical aircraft, powered-lift vertical takeoff and landing airplanes, air-breathing and rocket propelled missiles, and hypersonic vehicles. Analysis, wind tunnel tests, ground-facility tests, simulations and flight tests will be performed in FY 1983 to advance the state-of-the-art in the areas of aerodynamics, flight dynamics and controls, propulsion and airframe/propulsion integration.

NASA has continually been involved in the formative stages of advanced tactical aircraft developments, and has a long and productive history in evolving new concepts which have led to successful operational weapons systems. A cooperative program was undertaken with the General Dynamics Corporation to apply high-speed aerodynamics technology developed under the Supersonic Cruise Research program to the design of a new wing for the F-16 airplane. The NASA developed analytical/experimental supersonic aerodynamics tools and the expertise of NASA personnel were used to develop a new supersonic cruise and maneuver configuration with a high degree of commonality with the basic F-16 aircraft. As shown in Figure 44, this cooperative program led to the F-16E design to which General Dynamics has committed approximately $40 million to modify two Air Force supplied aircraft. During the last two years, NASA has extensively supported the development of the F-16E with wind tunnel tests at both Ames and Langley and with simulator tests. Figure 44 shows, for example, a supersonic model in the Unitary Plan Wind Tunnel at Langley. The actual F-16E, scheduled to fly in July 1982, is a modified version emphasizing commonality rather than supersonic performance. NASA is now initiating a concept formulation and experimental validation effort aimed at the next generation of advanced tactical aircraft. Evolving technologies such as active canard controls, non-axisymmetric nozzles, and flight/propulsion control integration will be explored. In FY 1983, analytical studies and wind tunnel model construction and testing will be emphasized.

Most concepts for future high-performance tactical military aircraft incorporate non-axisymmetric (two-dimensional) nozzles. In addition to their use for thrust vectoring, non-axisymmetric nozzles can efficiently integrate thrust

reversal capability within their design and thus offer improved landing rollout capability. These and other benefits, such as reduced infrared signature and reduced number of moving parts, make non-axisymmetric nozzles potentially attractive for advanced tactical aircraft. In recent years, NASA has made considerable progress in its research on non-axisymmetric nozzles (Figure 45), emphasizing low-aspect-ratio nozzles and including extensive cold air internal performance testing with small-scale models, wind tunnel tests of nozzle installations on various aircraft configurations, and the first initial altitude chamber tests of several nozzles on full-scale engines. Current activities include preliminary design studies and small-scale exploratory internal performance tests of high-aspect-ratio non-axisymmetric nozzle concepts. In addition, a cooperative activity with the Navy is underway to mate the Navy-developed Augmented Deflector Exhaust Nozzle with an F-404 engine for extensive testing in an altitude chamber at Lewis in FY 1983.

Advanced materials offer significant improvements to reduce the cooling requirements and weight of exhaust nozzles which must operate at the high temperatures associated with afterburning military engines. Carbon/carbon panels are currently being fabricated for the versatile two-dimensional convergent/divergent (2D/CD) research nozzle with which NASA has already completed initial testing on a J-85 jet engine. The carbon/carbon panel-equipped 2D/CD nozzle will also be tested in FY 1983 in the Propulsion System Laboratory at Lewis.

The military services, particularly the Navy, continue to show interest in and a need for subsonic and supersonic vertical/short takeoff and landing (V/STOL) aircraft capabilities. Ames, in cooperation with the Navy, has been conducting analytical studies and testing both small- and large-scale models in wind tunnels and on a static test stand. In addition, work is continuing on some of the critical propulsion related components, such as inlets, fans and vectoring exhaust nozzles. The objectives of this research are to acquire valid experimental data and to improve prediction techniques required for future V/STOL aircraft designs. Some of the areas being investigated include cross-flow effects on lifting jets and the static pressure on surfaces near the jet; ground effects on hover lift, flow circulation, and resulting potential inlet ingestion; scaling effects; and effects of ejectors, augmented lift devices and vectoring nozzles. Fundamental wind tunnel studies are utilizing lasers and other advanced diagnostic techniques to measure and help establish a basic understanding of the phenomena involved.

The major elements of NASA's activities on subsonic V/STOL aircraft are in aerodynamics, flight simulation, and propulsion components, as shown in Figure 46. The initial full-scale model subsonic tilt nacelle aircraft tests at low speeds in the 40x80-foot wind tunnel and on the static test stand at Ames were recently completed. The objectives

of these tests were to obtain low speed aerodynamic data and to evaluate aircraft controllability. In the tilt nacelles of the model were two TF-34 engines with control vanes in the fan exhaust. Simulations were also conducted to compare controllability predictions with test results, and it was determined that modifications to the configurations were necessary to improve controllability. These are currently being made, and this full-scale model will be tested in the new 80x120-foot section of this wind tunnel. In addition, an 11-percent scale model of the tilt nacelle V/STOL aircraft will be tested in other wind tunnels at Ames to obtain high-speed aerodynamic data and scaling effects. Computer modeling of this aircraft configuration is being modified and updated before further studies are performed in the Vertical Motion Simulator facility.

In the area of supersonic V/STOL aircraft research, the twin-engine supersonic fighter model testing, without propulsion simulators, was completed last year as shown in Figure 47. Powered model testing will occur in FY 1983 and subsequent critical component validation is planned. Also in FY 1981, the Navy and NASA jointly sponsored four contractors to study single-engine V/STOL fighter concepts. The study results were very promising and indicated the desirability of continuing with the next phase of this activity, which will include model testing of the most promising concepts to obtain aerodynamic performance and controllability data and to work on the ejector/augmentation systems required for enhanced lift under hover and transition flight conditions.

Generically applicable to advanced military tactical aircraft and powered-lift V/STOL aircraft is the Turbine Engine Hot Section Technology (HOST) program. A concentrated effort is underway to develop advanced analysis tools and to conduct "benchmark" experiments to accurately define the internal engine environment and determine engine structure responses to that environment. With the increased accuracy provided by these results, more efficient and durable engine structures can be designed and thereby increase engine hot section component life. A number of experiments are underway to determine actual internal engine conditions. The HOST program, illustrated in Figure 48, has implemented a newly developed high-temperature (1800^{o}F vs 750^{o}F currently) strain gage for mounting inside the engine. This gage required the evolution of new methods for measurement as well as new materials for the gage in this environment. Analytical methods are also being developed, including more accurate aerodynamic and thermal analyses of the hot gases and nonlinear large distortion structural analysis methods for engine vanes, blades and liners. Both the experimental and analytical methods will be verified in full-scale turbine thermal-mechanical component tests. Final results will then be used to analytically define life of hot section components. With accurate analysis methods available, future engine designs can be optimized without testing components as exhaustively as is currently standard in the engine industry.

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In the area of hypersonic vehicles with potential future military applications, NASA has been utilizing advanced aircraft concepts as a mechanism for integrating complex technologies in structures, materials, propulsion and aerodynamics. The aircraft configuration shown in Figure 49 is an example of one of these advanced Mach 5 aircraft concepts being investigated at Langley. This vehicle would fly at very high altitudes, with all leading edges operating at radiation equilibrium temperatures of 1100° to 1400°F, and would be constructed primarily of passively cooled, insulated titanium. The propulsion system would require dual-cycle turbojet/ramjet engines to provide takeoff capability, acceleration through the transonic drag rise region, and low fuel consumption at cruise conditions. The high heat loads imposed on the engine compartment would require consideration of active cooling for this area. Since hydrocarbon fuels have very limited cooling capability, cryogenic liquid methane and liquid hydrogen, which are extremely effective as coolants and also provide performance benefits over hydrocarbon fuels, are being studied for such a hypersonic aircraft. In exploring hypersonic aircraft concepts, NASA is concentrating on techniques for integration of large inlets and nozzles dictated by the low air densities associated with very high altitudes. Advanced analytical techniques and computational procedures are being developed to handle the design and analysis of the unique and innovative configurations that are now beginning to evolve, and further efforts will be made to refine and validate these prediction methods.

In addition to research efforts related to high-speed military airplanes, NASA has a continuing effort to improve analytical methods and to establish a valid supersonic aerodynamics data base for a large variety of high-speed missiles. During the 1970's, a coordinated NASA/Navy/Air Force effort was undertaken to generate basic parametric data for cylindrical-body/cruciform-fin configurations. One of the models tested in the supersonic Unitary Plan Wind Tunnel at Langley is shown in the upper left of Figure 50. The results of this research were used in the assessment and design of the two competitive Advanced Medium Range Air-to-Air Missiles (AMRAAM) which were recently flight tested and one of which will now go into production for both the Navy and the Air Force. Currently, NASA is concentrating on high-speed wind tunnel tests of the Advanced Common Intercept Missile (ACIM), which is a long-range air-to-air missile. The model used for parametric testing is shown in the lower left of Figure 50. High-speed testing of the Hypersonic Surface-to-Air Missile (HYSAM) is shown in the upper right of the figure. Both missiles are related to Navy interests. Also shown is a sketch of an advanced configuration with superior aerodynamic performance, stability and control characteristics. Such a configuration could be applicable to future air-to-surface missiles. A model is under construction and will be tested at Langley in FY 1983.

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Flight research is a significant element of NASA's High-Speed Aircraft Technology program and is the "real world" test of new concepts and advanced technologies. All major flight research activities are performed jointly with DOD organizations or directly in response to military agency requests. A highly successful project to date has been the flight tests of an F-15 testbed aircraft equipped with an F-100 engine incorporating a Digital Electronic Engine Control (DEEC) system. These tests were conducted by the Ames/Dryden Flight Research Facility (DFRF) at the request of the Air Force. This activity, illustrated in Figure 51, achieved the free-world's first operation of an engine-mounted, full-authority digital engine controller in a high-performance military aircraft when the DEEC-equipped F-15 aircraft made its first flight in June 1981. Flight research to fully evaluate the controller, demonstrate the engine no-trim control logic, establish improved augmentor operation at low Mach numbers and high altitude, and demonstrate improved air start capability is scheduled to be completed by June 1982. Digital electronic engine control technology, which offers improved control accuracy and fuel savings, increased engine operating envelope, lower weight, fewer parts and improved reliability, and maintainability will have been significantly advanced and proven at the completion of these NASA flight tests.

A major ongoing flight research activity has been the Highly Maneuverable Aircraft Technology (HiMAT) program, which is jointly sponsored by the Air Force and NASA. Since the first flight of HiMAT vehicle number 1 on July 27, 1979, the two HiMAT remotely piloted research vehicles have successfully completed a total of 13 flights at DFRF. A major portion of the design operating envelope has been cleared, as shown in Figure 52. A series of supersonic flight tests will be conducted out to the design point of Mach 1.4.

Flight test data have been acquired in the areas of stability and control, flight controls, structures, flutter and propulsion. Initial data analysis of the effect of aeroelasticity on the vehicle's stability indicates that the degradation due to aeroelastic deformation of the wings was not significant. This indicates the methods used to predict aeroelastic effects are not yet well understood. The wing bending data shown in Figure 53 could provide an explanation for the reduced deformation. Wing and canard flight loads have been measured up to load factors of 8 g's. A nonlinearity in wing bending was observed at 5 g's and above 8 g's. In-flight tuft data indicated regions of flow separation at these flight conditions which support the reduced wing-deflection results. Even though the loads and deflection data are less than predicted, preliminary flight data indicates maneuvering performance is not significantly degraded. HiMAT flight tests are scheduled to be completed in FY 1982, and analysis of the detailed data will be accomplished in FY 1983.

The joint Air Force/NASA Advanced Fighter Technology Integration (AFTI) effort consists of two elements: the AFTI/F-16 and the AFTI/F-111 Mission Adaptive Wing (MAW) projects. The AFTI/F-16, incorporating an advanced digital fly-by-wire control system and canard surfaces for direct force control, will develop, integrate and flight validate these technologies for future fighter applications. The primary Air Force objective is to couple the flight control system and direct force control capabilities to enhance controls technology for military missions. NASA's interest is in evaluating the advanced control techniques, the aerodynamics of the direct force control, and the man/machine interface. Langley has supported the AFTI/F-16 program through wind tunnel tests, and DFRF is responsible for the joint flight tests and data analyses. First flight of the AFTI/F-16 aircraft is scheduled for the Spring of 1982 and will continue during FY 1983.

The AFTI/F-111 (MAW) will demonstrate the aerodynamic performance improvements of a smooth, variable-camber airfoil on an F-111 aircraft. A supercritical wing design has been developed that allows great variability in wing camber using smooth leading- and trailing-edge devices so that the airfoil can assume many shapes for optimum performance over a wide operating envelope: cruise, maneuver, and penetration. The Air Force is responsible for the acquisition of the AFTI/F-111 (MAW) and NASA's role is to perform the wind tunnel tests at Langley and to conduct the flight tests at DFRF. First flight of the AFTI/F-111 (MAW) aircraft is scheduled for FY 1983.

NASA's support to the DARPA-funded X-29A Forward Swept Wing Flight Demonstrator program will increase in FY 1983 to help ensure successful initial flights which are scheduled to occur in early FY 1984. Currently, NASA is working closely with DARPA, in accordance with an agreement signed in April 1981, and the Air Force, its agent for the procurement of the X-29A aircraft. Previous and current activities, shown in Figure 54, include aeroelasticity tests in the Langley Transonic Dynamics Tunnel, low- and high-speed aerodynamic and inlet wind tunnel tests at Ames and Langley, and flying qualities simulation studies using the specialized capabilities of the Differential Maneuvering Simulator at Langley. Under the DARPA/NASA agreement, NASA will be responsible for the government flight tests of the X-29A which will occur at DFRF. Considerable flight-test support preparation work will be done at DFRF in FY 1983 to ensure that this responsibility can be carried out in a safe, timely and efficient manner.

Aircraft Energy Efficiency Program Status

The Aircraft Energy Efficiency (ACEE) program began in 1976 at the request of Congress. The program was structured to accelerate both the development and application of fuel saving technology to transport aircraft in view of the large projected worldwide markets for civil transports and the need for improved military cargo and tanker aircraft. The stated goal of the six-element program was to provide new technology that, if implemented, could reduce fuel consumption by 50 percent relative to the first-generation widebody aircraft and engines.

The six elements comprising the ACEE program are the Engine Component Improvement (ECI), Energy Efficient Engine (EEE), Advanced Turboprop (ATP), Energy Efficient Transport (EET), Composite Primary Aircraft Structures (CPAS), and Laminar Flow Control (LFC) programs. Of the six programs, ECI completed testing in FY 1981. The ECI program successfully reached its goal of approximately 5-percent reduction in specific fuel consumption through improved components and maintenance procedures for current production engines. In February 1982, the third payment will be received by the government under the cost recoupment provisions of the ECI contracts.

Significant progress has been made in each of the remaining five program elements. It is anticipated that application of the technolgy developed thus far will yield both short- and long-term benefits.

The following sections provide the current status of the work in each ongoing ACEE program element.

The Energy Efficient Engine (EEE) program has the objective of developing and demonstrating advanced technology for a new generation of fuel efficient turbofan engines that offer 15-percent reduction in fuel consumption, at least 5-percent reduction in direct operating costs, 50-percent improvement in performance retention, and reduced environmental impact compared to current high-bypass-ratio commercial turbofan engines. The EEE program is developing component and systems technologies that are being evaluated and verified in rig and systems tests. In FY 1981, each of the major components was tested with excellent results as part of the component technology development effort, which is nearing completion. The highly advanced General Electric high-pressure compressor exceeded efficiency and pressure-ratio goals during its first rig test. General Electric has also performed a fan rig test which resulted in efficiency levels that exceeded fully developed component goals. Other components that have been successfully tested include: the Pratt & Whitney high-pressure compressor, shown in Figure 55; the General Electric low-pressure turbine; and the combustors, high-pressure turbines, and exhaust gas mixers of both contractors. The results of these component rig tests indicate that the program system technology goals should be attained with significant margin.

The effort to determine overall system performance has been descoped, as indicated in Figure 55. Currently, the high-spool components at General Electric are being assembled with other required subsystems as a core engine for testing. The test, beginning near the end of FY 1982 and continuing into FY 1983, will provide the steady-state and dynamic performance of the engine gas generator. Integrated core/low-spool tests were planned for early FY 1983 at both General Electric and Pratt & Whitney. These initial tests would provide performance evaluation of the high- and low-spool components in a realistic engine environment.

During FY 1983, plans will be initiated to bring the EEE hardware in-house to Lewis as advanced technology testbeds. These testbeds will provide a valuable focal point for future in-house propulsion system research and for potential cooperative research efforts with industry. Potential research areas include active clearance control, transient rotor dynamics, component interaction/matching, stall recovery, advanced multivariable controls, improved turbine cooling and engine structures.

The Advanced Turboprop (ATP) program has provided initial confirmation of early predictions of performance characteristics. The stated goal of 15- to 20-percent fuel savings relative to turbofan powered aircraft of equivalent technology was based on estimates of propeller (prop-fan) efficiency, installation drag, and noise reduction weight penalty. The ATP program was structured to explore each of these areas, conducting baseline experiments and evaluating performance optimization. Prop-fan efficiency estimates were confirmed in Phase I (FY 1978-1980). Experimental programs utilizing prop-fan wind tunnel models with maximum-sweep blades, wing/nacelle/propeller wind tunnel models, large-scale fuselage sections, and a subscale propeller installation on a JetStar aircraft were initiated and brought to their test phases during FY 1981 and early FY 1982.

As indicated in Figure 56, significant efforts have been initiated in most ATP program areas. Propeller research, in addition to establishing the attainability of 80-percent efficiency at Mach 0.8 cruise speed, has provided a comprehensive data base of aerodynamic, acoustic, and aeroelastic characteristics for several blade shapes. Recent tests of subscale models in the Lewis 8x6-foot wind tunnel have investigated the effect of blade-tip sweep on high-speed flutter boundaries. One consequence of this increased understanding of the flutter phenomenon is greater confidence in the structural design concepts being analyzed for large-scale prop-fan research. In FY 1982, we plan to initiate the design, fabrication and test of an aeroelastically scaled two-foot diameter prop-fan model as a step toward understanding large-scale structural dynamics of the propeller concept.

The planned work in acoustics and installation aerodynamics must be limited in order that the one unique element of the technology, the propeller or prop-fan, may continue to be investigated. Two types of noise research have produced favorable indications that a satisfactory passenger cabin environment can be attained without serious weight penalty. In-flight experiments on the JetStar aircraft, with a two-foot prop-fan model mounted above the fuselage, have evaluated source noise at up to Mach 0.8 cruise speed and 35,000 feet altitude. Sound pressures impinging on the fuselage were indicated to be lower than predicted. Ground experiments, using a Swearingen Metro fuselage test section in an anechoic chamber, have indicated that fuselage wall treatment concepts are more effective in attenuating low-frequency noise than analytically predicted. Large-scale ground experiments and analytical optimization must be deferred in the descoped program.

The aerodynamic efficiency of turboprop propulsion system installation on an aircraft wing is the subject of a series of wind tunnel investigations. Initial experiments with a nacelle on a supercritical wing (without propeller) indicated that simple fillets can significantly reduce interference drag. Analyses based on wind tunnel pressure measurements predicted that nacelle and wing contouring in accordance with local flow patterns may effectively eliminate interference drag. A current series of powered tests in the Ames 11-foot wind tunnel and a recent unpowered (nacelle and wing) test in the Ames 14-foot wind tunnel indicate that the analytical predictions can be achieved by further optimization. Additional tests in this program are planned, but the rate of progress will be slow.

The Energy Efficient Transport (EET) program, begun in 1976, has provided a national research focus on subsonic transport aircraft energy efficiency in the technical disciplines of advanced aerodynamics and active controls. The research concentrated on providing an adequate data base and proof-of-concept, enabling the Nation's aeronautical community to analyze and incorporate new ideas into derivative or new transport designs. The program has been highly successful in achieving its goal of developing technology which, when applied, could result in significant fuel efficiency improvements.

Progress to date in the EET program is summarized in Figure 57. At Lockheed, an active controls system known as maneuver load alleviation (Figure 57, upper left) permitted the wing span of the L-1011 to be extended about 6 percent without structural modification. This increase in wing aspect ratio would produce a 3-percent improvement in fuel efficiency if applied operationally. A second active controls concept, pitch augmented stability, is also undergoing flight research for another projected 3-percent improvement.

In winglet flight research, the EET program supported the Air Force KC-135 winglet flight research demonstration with detailed aerodynamic design, wind tunnel tests and flight tests at DFRF. Results showed fuel savings of 6 percent are possible with application of only the upper winglet to the KC-135 tanker aircraft.

At Douglas, both upper and lower winglets have been flight tested on a DC-10-10 transport (Figure 57, lower left). A NASA design was tailored for potential retrofit to the DC-10-10 aircraft. In flight research, unpredicted low-speed buffet was encountered in addition to slightly lower performance than estimated from wind tunnel tests. To solve these problems, a winglet leading-edge Krueger device was installed which reduced low-speed buffet to a satisfactory level but added complexity. Drag improvements of 6 percent at low speeds and 2.5 percent at high-speed cruise were achieved. However, these problems point to the inadequacy of current analytical and wind tunnel predictive capabilities.

At Boeing, the major EET advanced technology activity has been in Integrated Application of Active Controls (IAAC) (Figure 57, lower right). In-depth analysis, using the latest state-of-the-art in transport design, indicates that active controls hold the potential for 8- to 10-percent greater fuel efficiency than current controls technology. The final active control configuration (the left half of the planform) visibly differs from the baseline (the opposite half) by having a higher aspect-ratio wing located further forward on the fuselage and smaller vertical and horizontal tail surfaces. Rearward location of the center of gravity, which reduces drag, is made possible by the use of an active pitch augmented stability system.

In NASA laboratories, a large data base has been established on the aerodynamic and aeroelastic characteristics of highly fuel efficient wing designs incorporating aspect ratios of 10 to 12, supercritical airfoils, reduced wing sweep, and winglets (Figure 57, upper right). The compatibility of high-lift control surfaces with advanced active control functions has been investigated and a wind tunnel data base established for public use. High-bypass turbofan installation effects on aerodynamic characteristics have been investigated and important sensitivities have been documented.

Pioneering research into fault-tolerant computers or "no downtime" concepts has made great strides within the EET program. These computers will not only do a myriad of functions but will also detect faults and correct them by diverting from less essential to more critical functions. NASA has established a laboratory for future research into the reliability of complex aircraft computer systems. The EET program has developed engineering models of "no downtime" computers from which laboratory procedures will be established for future research in NASA's Controls and Guidance R&T program.

The remaining EET activities include the Lockheed flight evaluations which will be completed and documented. All documentation on the Douglas and Boeing contracted activities will be completed in FY 1983. The Boeing IAAC system will be assembled, tested in the laboratory, and turned over to Boeing for flight test.

The Composite Primary Aircraft Structure (CPAS) program has achieved a number of major milestones through FY 1982 which contribute significantly to composites technology and include completion of the secondary structures programs, with over 20 new components in flight service, and a completion of structural ground test, FAA certification, and flight checkout of medium-primary composite components. These achievements have provided a major impetus to the introduction of highly loaded composite structures on a number of emerging aircraft, such as the B-767, B-757, Lear Fan 2100, and proposed C-17. More importantly, these programs are providing a firm and comprehensive technical base for advancing the technology to heavily loaded wing and fuselage primary structures where the full potential composite benefits of 10- to 15-percent lower fuel consumption and lower maintenance can be achieved.

All composite secondary structure elements (B-727 elevator, DC-10 upper rudder, and L-1011 inboard aileron) have been completed, the components have been FAA certified, and thousands of flight hours have been accumulated in airline service (Figure 58).

Progress in the medium-primary stabilizer efforts (B-737 horizontal, DC-10 vertical, and L-1011 vertical) has defined the technology challenges inherent in composite structures development, lifetime assurance, and certification (Figure 59). The B-737 horizontal stabilizer completed all tests for FAA certification, and five ship-sets of components will be in flight service by mid-year. The L-1011 vertical stabilizer, which experienced a premature failure in ground tests, has been repaired and will continue through both static and fatigue ground tests. Spar and skin sub-components of the L-1011 stabilizer are approaching 15 years of life simulation in environmental chambers. The DC-10 vertical stabilizer failed early in static ground tests at limit load. This failure requires a complete re-analysis and structural reinforcement. Static and fatigue ground tests will continue, and a second article will be test flown. Discrepancies between the structural analysis and the early test failures are not yet fully understood.

Key technology efforts for large primary structures are independently studying critical technical issues of thick joints, fuel containment, and durability and damage tolerance for composite wing structures. These efforts are developing generic, 1990's-type wing design data and are cooperatively distributing the technology across the industry.

Available FY 1982 CPAS funds will be used to continue activities into 1983. The DC-10 and B-737 stabilizers will be on scheduled airliners accumulating flight service data, and the L-1011 stabilizer spar and skin sub-components will complete 20 years of simulated environmental testing. The key technology activities will complete coupon and small element tests to define a data base for the detail design of a composite wing.

While composite secondary structures have been validated as state-of-the-art and gained acceptance for both civil and military aircraft, medium-primary composite structure components have experienced sufficient development difficulty to indicate that the design technology for large, strength-critical composites is not yet in hand. Premature failure of major composite components in ground tests confirm the need for a better understanding of the design, fabrication, and test technology. There is also some indication that size has a major influence on load introduction and distribution for thick, highly-loaded structures which cannot presently be evaluated on less than full-scale, full-size test components.

Although successful and significant progress has been made in the Composite Primary Aircraft Structures program, it is clear that the technology for large, highly-loaded, safety-of-flight critical composite structures is insufficiently established to support consideration for aircraft incorporation. The present state-of-the-art represents about 1- to 3-precent aircraft weight savings, with the full potential of up to 15-percent weight reduction dependent upon technology development for large, heavily-loaded composite structures.

NASA has been engaged in the development of Laminar Flow Control (LFC) systems technology for several years with the goal to develop and demonstrate a practical, reliable, maintainable LFC system concept for future commercial transport aircraft. In the initial program phase, NASA, through contracts with industry, conducted investigations to determine the optimum configuration for a long-range transport featuring LFC. Appraisals were made of alternative concepts, and the most feasible were selected for further investigation. Realistic assessments were made of the economic aspects of the aircraft with regard to manufacturability, operational reliability and maintenance. Potential benefits have been defined. The conclusion was that a practical and economical LFC transport with fuel savings on the order of 20 percent could be developed. However, these activities revealed critical issues concerning the practicality of LFC. A second phase of the program was planned to address these issues through wing leading-edge flight tests, wing surface systems development and wind tunnel experiments.

In the leading-edge flight test, the operational practicality of LFC systems for future transports is being examined in the most sensitive region, the wing leading edge.

Representative LFC leading-edge wing boxes are being fabricated and will be installed on the NASA JetStar, as illustrated in Figure 60, and flight tested. The aircraft will commence operating in 1983 in different geographical locations and meteorological conditions. This activity, although limited to the wing leading edge, will allow examination of operational issues that would be critical in airline service, such as the requirement to keep the leading edge clean. Figure 60 shows the locations of washing slots and spray nozzles on the two leading-edge configurations to be tested.

Another activity in the program is the verification of structural concepts and demonstration of the integrated LFC system in the wing surface of a future transport. Representative sections of the wing surface were selected which are typical of the wing surface of a long-range transport. These are being fabricated to allow a realistic assessment of not only wing design but also whether these wing panels can be built on a production line with the demanding LFC surface smoothness criteria and within acceptable costs.

CONCLUSION

This concludes my discussion of the NASA FY 1983 Aeronautical Research and Technology Program and Budget. I reiterate my appreciation of your help in focusing attention on the importance of this program which provides major contributions to the national economy and to national security. We believe that our planned program will continue to maintain the United States at the forefront of aeronautics, for both military and civil applications. We will continue to advance the technology base in all key aeronautical disciplines and will encourage industry to accelerate their participation in the development process. We intend to continue to build an aeronautical research program and supporting facilities that we can all be proud of and one that will preserve our leadership in world aviation.

AERONAUTICS RESEARCH & TECHNOLOGY

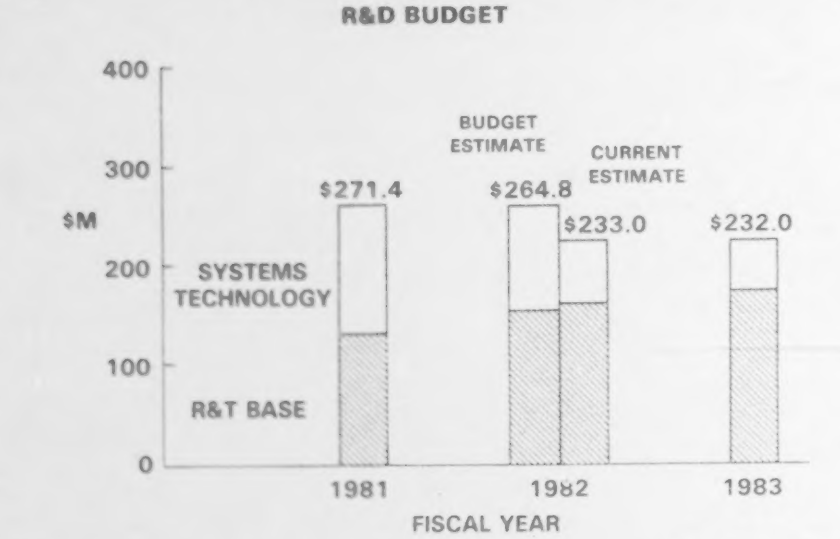
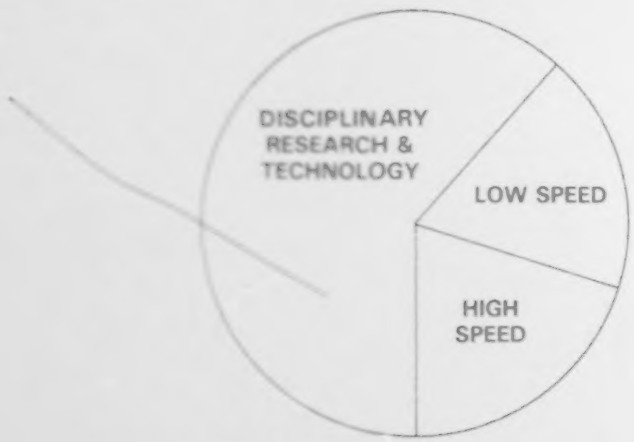


Figure 1

AERONAUTICS RESEARCH & TECHNOLOGY



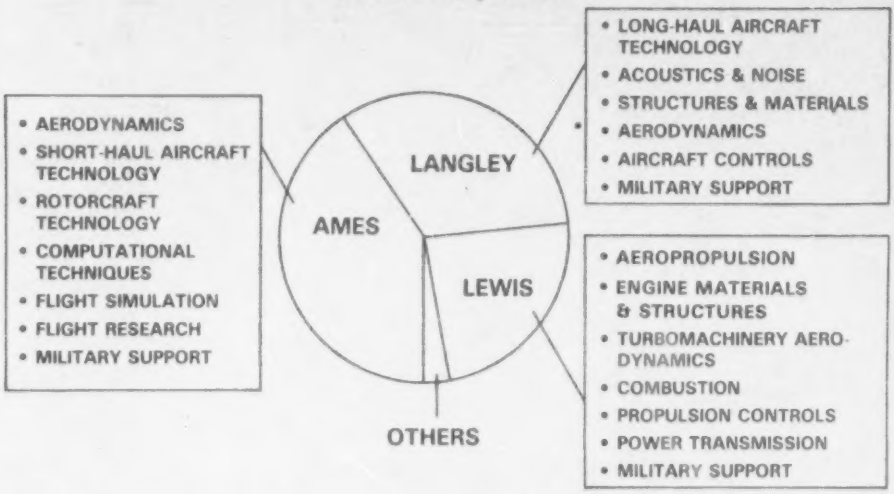
FY 1983 R&D BUDGET
($232.0 M)

NASA OAST

Figure 2

AERONAUTICS RESEARCH & TECHNOLOGY

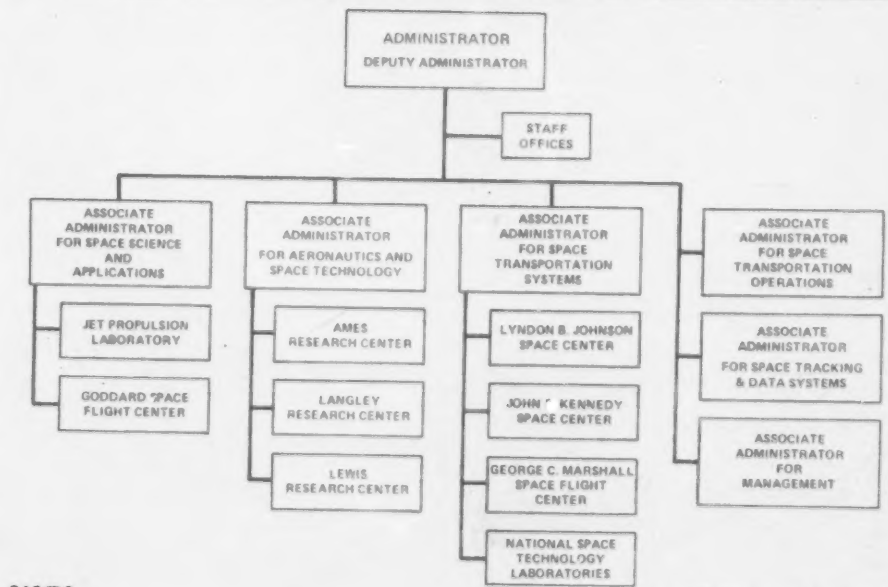
CENTER FUNDING DISTRIBUTION AND ROLES
(R&D – $232.0 M)



NASA OAST NASA HQ R82 501(3) REV. 2 2 82

Figure 3

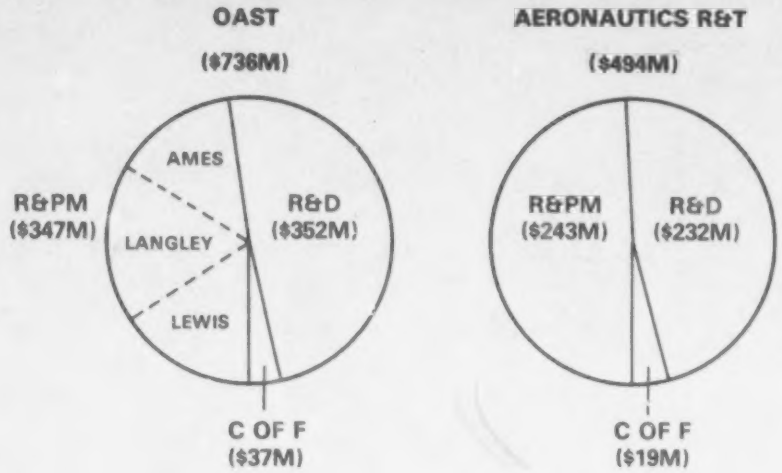
NASA ORGANIZATION


ADMINISTRATOR
DEPUTY ADMINISTRATOR
STAFF OFFICES
ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS
JET PROPULSION LABORATORY
GODDARD SPACE FLIGHT CENTER
ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY
AMES RESEARCH CENTER
LANGLEY RESEARCH CENTER
LEWIS RESEARCH CENTER
ASSOCIATE ADMINISTRATOR FOR SPACE TRANSPORTATION SYSTEMS
LYNDON B. JOHNSON SPACE CENTER
JOHN F. KENNEDY SPACE CENTER
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL SPACE TECHNOLOGY LABORATORIES
ASSOCIATE ADMINISTRATOR FOR SPACE TRANSPORTATION OPERATIONS
ASSOCIATE ADMINISTRATOR FOR SPACE TRACKING & DATA SYSTEMS
ASSOCIATE ADMINISTRATOR FOR MANAGEMENT

NASA OAST NASA HQ 82R 512(3) 1 18 82

Figure 4

OAST INSTITUTIONAL AND PROGRAM RESOURCES



NASA

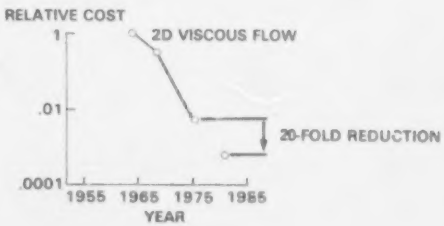
OAST NASA HQ R 510(3) REV 2 2 82

Figure 5

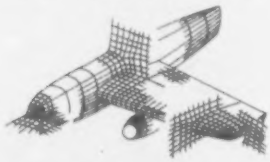
AERODYNAMICS

COMPUTATIONAL FLUID DYNAMICS

PROGRESS



3-D VISCOUS FLOWS



- ALGORITHM DEVELOPMENT
- GEOMETRIC MODELING
- GRID GENERATION

COMPUTER ADVANCES

- ADVANCED ARCHITECTURE
- IMPROVED SOFTWARE
- INTERACTIVE GRAPHICS

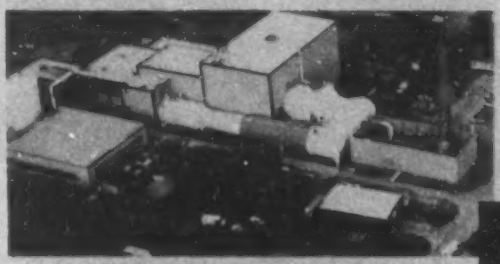
NASA

OAST NASA HQ R182 473(3) REV 2 2 82

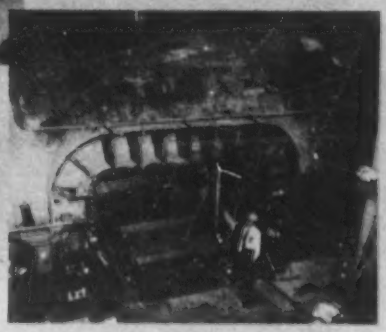
Figure 6

AERODYNAMICS

NATIONAL TRANSONIC FACILITY (LANGLEY)



- CONSTRUCTION NEARLY COMPLETE
- CHECKOUT IN PROGRESS
- R&D TESTS BEGIN FY 1983



NASA

Figure 7

OAST NASA HQ RT82 474(3) 1-15-82

AERODYNAMICS

DRAG REDUCTION

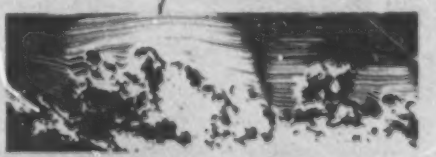
LARGE EDDY BREAK-UP DEVICES

CONTROLLED TURBULENT BOUNDARY LAYER

20% REDUCTIONS MEASURED

EXTEND TO HIGHER REYNOLDS NUMBERS

TEST ON AIRFOILS



FULLY-TURBULENT BOUNDARY LAYER

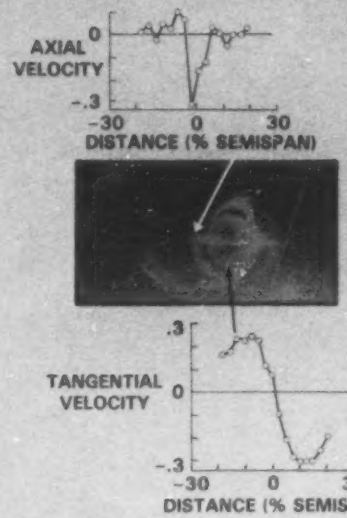
NASA

Figure 8

OAST NASA HQ RT82 474(3) REV. 2-3-82

AERODYNAMICS

WAKE VORTEX ALLEVIATION



LABORATORY TEST AND ANALYSIS

IMPROVE PREDICTIVE CAPABILITY

DEVELOP DESIGN CRITERIA

NASA

OAST NASA HQ RTS2-470(3) REV. 2-2-82

Figure 9

AERODYNAMICS

SUPERSONIC/HYPERSONIC RESEARCH

ADVANCED WING CONFIGURATIONS

INCREASED RANGE AND MANEUVERABILITY

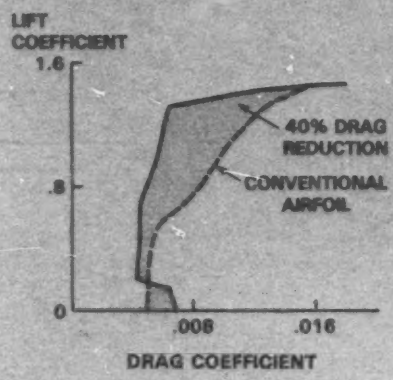
NASA

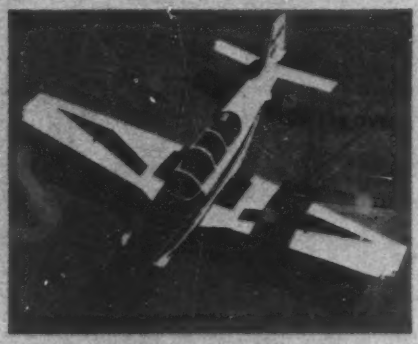
OAST NASA HQ RTS2-640(3) REV. 2-2-82

Figure 10

AERODYNAMICS

GENERAL AVIATION—NATURAL LAMINAR FLOW





T-34 LAMINAR FLOW GLOVE TESTS

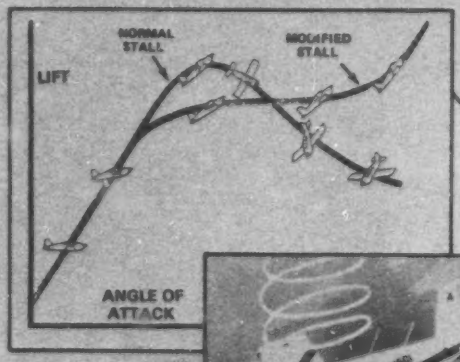
NASA

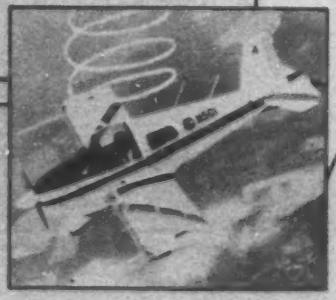
Figure 11

OAST

AERODYNAMICS

GENERAL AVIATION STALL/SPIN RESEARCH





WING REDESIGN

THEORETICAL ANALYSIS

PLUS

STALL/SPIN RESISTANT AIRPLANE DESIGN

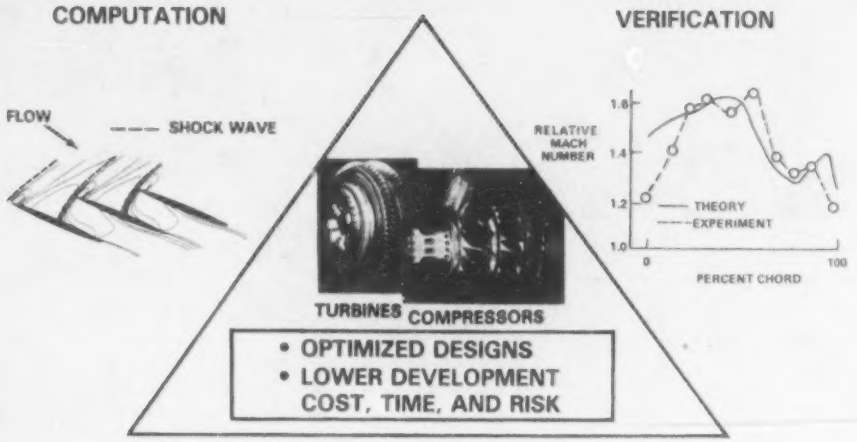
NASA

Figure 12

OAST

PROPULSION

INTERNAL COMPUTATIONAL FLUID DYNAMICS



NASA

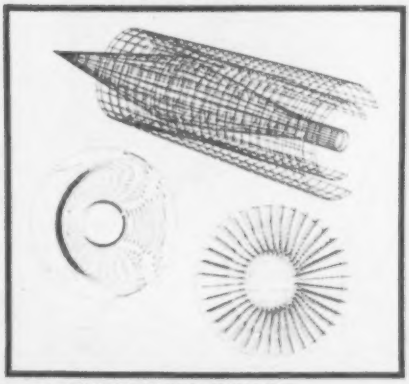
OAST

Figure 13

PROPULSION

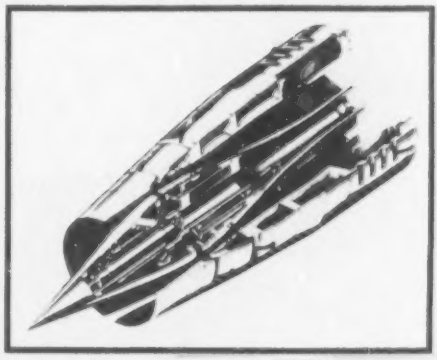
HIGH-SPEED INLET AERODYNAMICS

FLOW MODELING



• DEVELOP 3D SHOCK BOUNDARY LAYER PREDICTIONS

VERIFICATION EXPERIMENTS



• EVALUATE ANGLE OF ATTACK EFFECTS

NASA

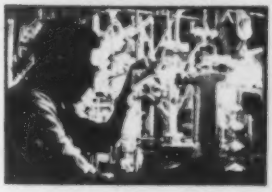
OAST

Figure 14

PROPULSION

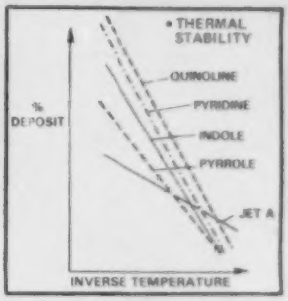
FUELS RESEARCH

CHEMICAL PROPERTIES



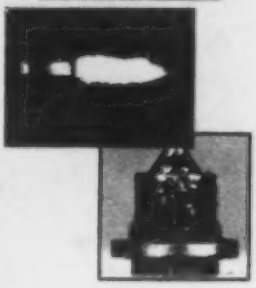
- H/C RATIO
- SULFUR CONTENT
- NITROGEN CONTENT
- TRACE ELEMENTS

PHYSICAL PROPERTIES



- BOILING RANGE
- VISCOSITY
- FREEZING POINT
- FLASH POINT

ENGINE PROPERTIES



NASA

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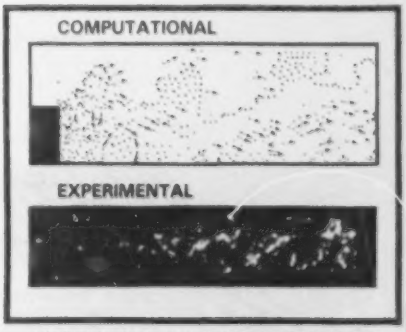
Figure 15

PROPULSION

COMBUSTION RESEARCH



MODELING AND VERIFICATION

DIAGNOSTICS

IMPROVED PERFORMANCE

NASA

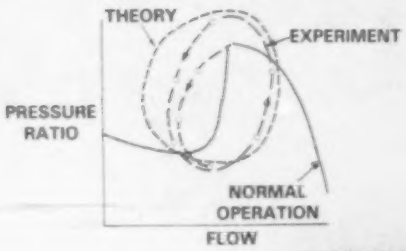
OAST NASA HQ R182 458(3) REV 2 2 82

Figure 16

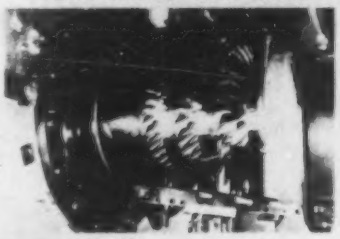
PROPULSION

STALL RECOVERY

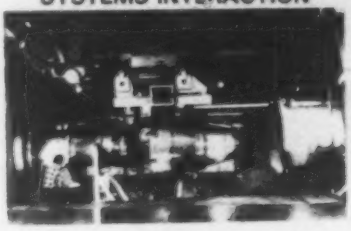
DYNAMIC ANALYSIS



COMPONENT MODELING



SYSTEMS INTERACTION



NASA

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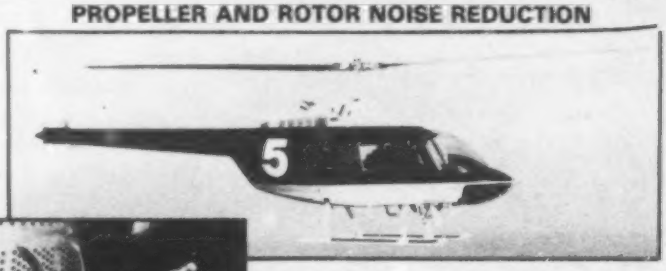
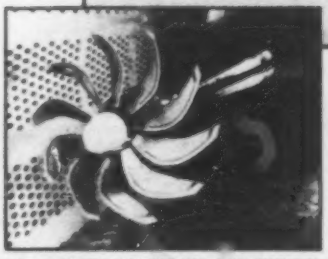
Figure 17

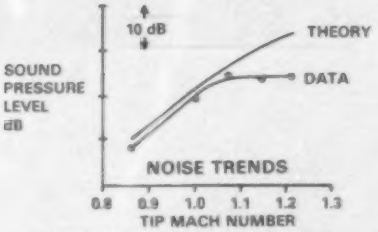
PROPULSION

PROPELLER AND ROTOR NOISE REDUCTION





• UNDERSTAND NOISE GENERATION



• IMPROVE PREDICTIVE CAPABILITY

NASA

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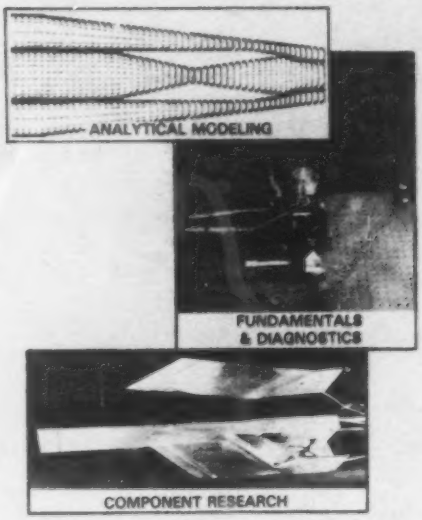
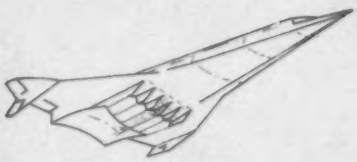
Figure 18

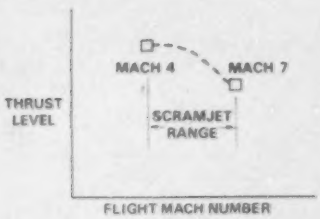
PROPULSION

HYPERSONIC RESEARCH





DEMONSTRATE SCRAMJET THRUST



NASA

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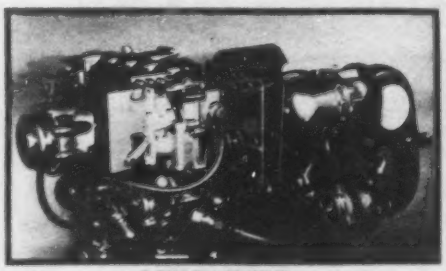
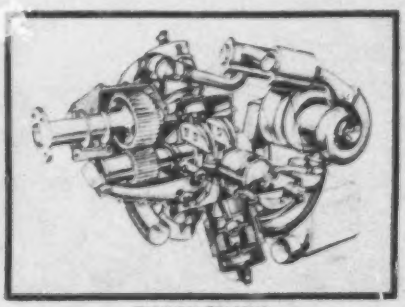
Figure 19

PROPULSION

ADVANCED TECHNOLOGY GENERAL AVIATION ENGINES



ROTARY ENGINE



PISTON ENGINE

- JET FUEL CAPABILITY VIA STRATIFIED CHARGE
- IMPROVED EFFICIENCY
  - REDUCED FUEL CONSUMPTION 25%
  - REDUCED WEIGHT 33-50%
- HIGH ALTITUDE CAPABILITY

NASA

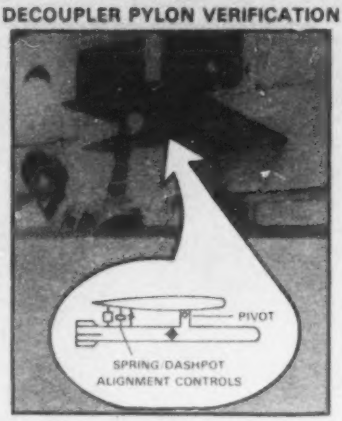
OAST NASA HQ RTB2 457(3) REV. 2.2.82

Figure 20

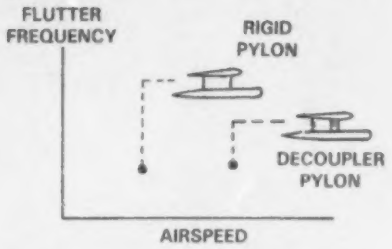
MATERIALS AND STRUCTURES

WING/STORE FLUTTER SUPPRESSION

DECOUPLER PYLON VERIFICATION



- INCREASED FLUTTER SPEED 40 PERCENT



FABRICATE HARDWARE FOR FY 84 FLIGHT EVALUATION

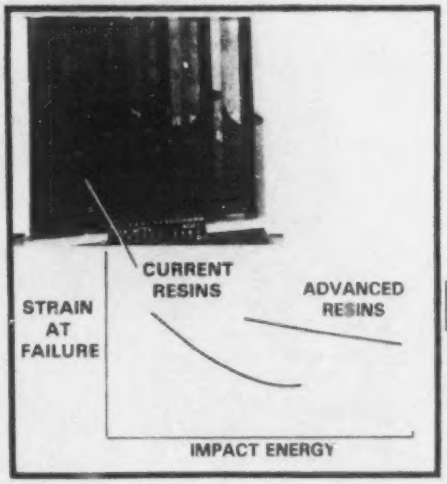
NASA

OAST NASA HQ RT82-447(3) REV. 2-2-82

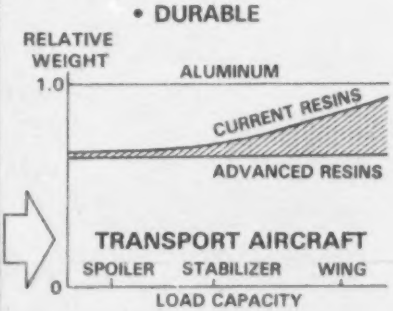
Figure 21

MATERIALS AND STRUCTURES

ADVANCED COMPOSITES



- TOUGH
- PROCESSABLE
- DURABLE



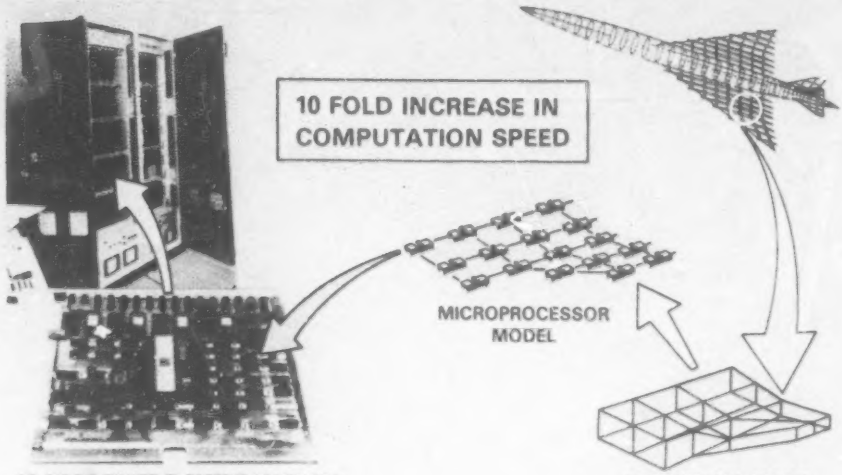
NASA

OAST NASA HQ RT82-454(3) REV. 2-2-82

Figure 22

MATERIALS AND STRUCTURES

COMPUTATIONAL STRUCTURAL ANALYSIS



NASA

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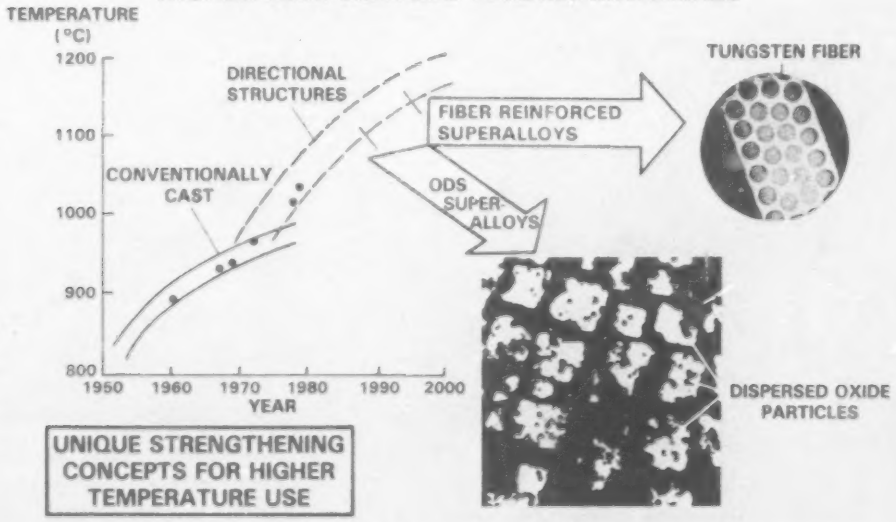
Figure 23

MATERIALS AND STRUCTURES

HIGHER TEMPERATURE TURBINE MATERIALS



UNIQUE STRENGTHENING CONCEPTS FOR HIGHER TEMPERATURE USE

NASA

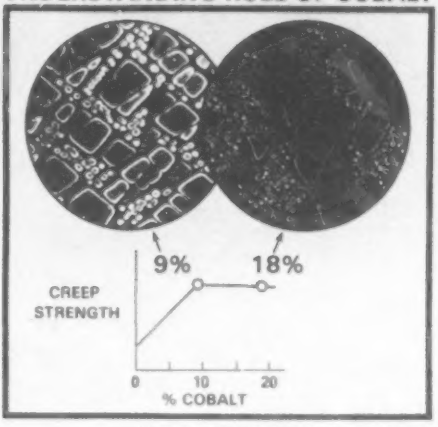
OAST NASA HQ RTB2 448(3) REV. 2-2-82

Figure 24

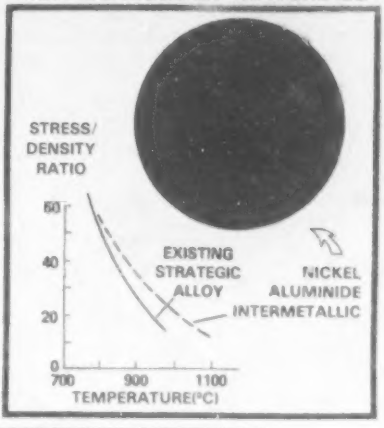
MATERIALS AND STRUCTURES

STRATEGIC MATERIALS RESEARCH

UNDERSTANDING ROLE OF COBALT



NEW CLASSES OF MATERIALS



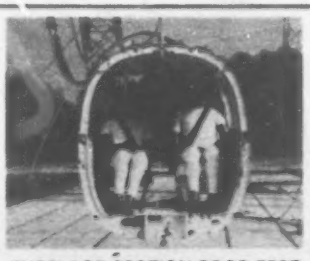
OPPORTUNITIES FOR REDUCTION/SUBSTITUTION

NASA OAST

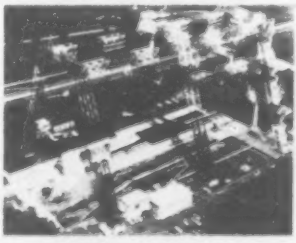
Figure 25

MATERIALS AND STRUCTURES

GENERAL AVIATION CRASHDYNAMICS

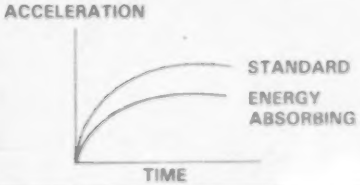


FUSELAGE SECTION DROP TEST



AIRCRAFT IMPACT TESTS

ENERGY ABSORBING CONCEPTS



NASA OAST

Figure 26

MATERIALS AND STRUCTURES

POST CRASH FIRE SURVIVABILITY

NEW FIREWORTHY MATERIALS

- SIDEWALL AND CEILING PANELS
- WINDOWS
- SEAT CUSHIONS AND FIRE BLOCKING LAYERS
- FLOOR PANELS

FULL SCALE TESTING

- CONTEMPORARY AND ADVANCED INTERIORS IN FAA AIRCRAFT SIMULATOR

FIRE MODELING TECHNIQUES

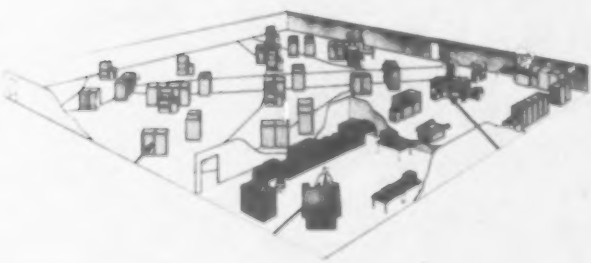
NASA

Figure 27

OAST NASA HQ RTB2 472(3) REV 2 3 82

CONTROLS & GUIDANCE

FAULT TOLERANT ELECTRONIC CONTROLS RESEARCH



- ARCHITECTURAL CONCEPTS
- FAULT TOLERENT SOFTWARE
- ANALYTICAL TECHNIQUES

OPERATIONAL FY 1983

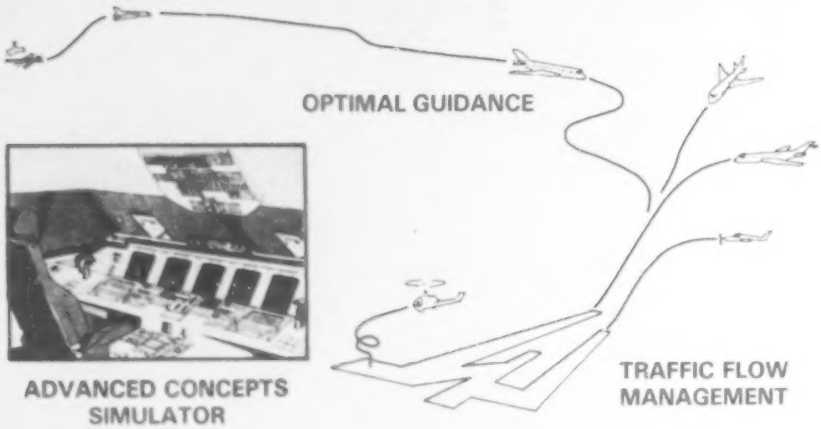
NASA

Figure 28

OAST NASA HQ RTB2 466(3) REV 2 2 82

CONTROLS & GUIDANCE

FLIGHT PATH GUIDANCE

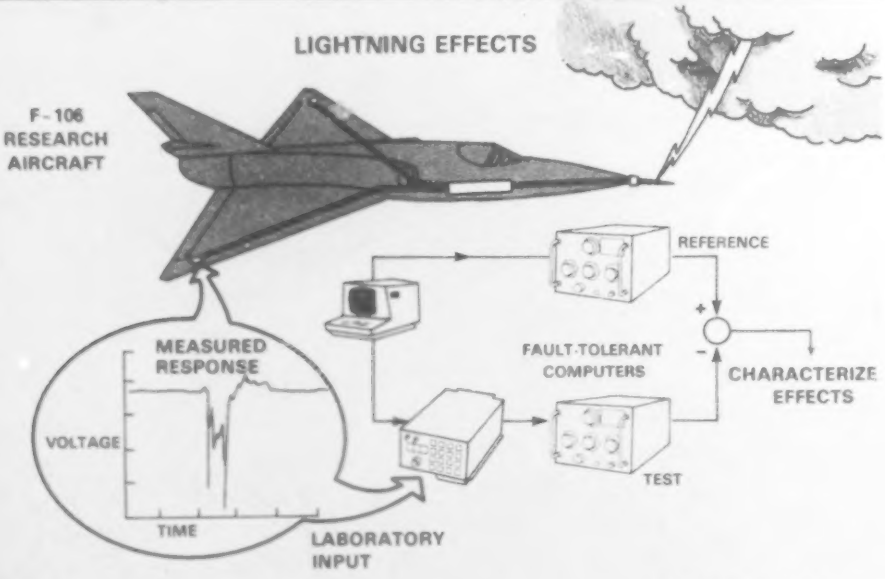


NASA

OAST NASA HQ RTB2 471(3) REV 2282

Figure 29

CONTROLS & GUIDANCE



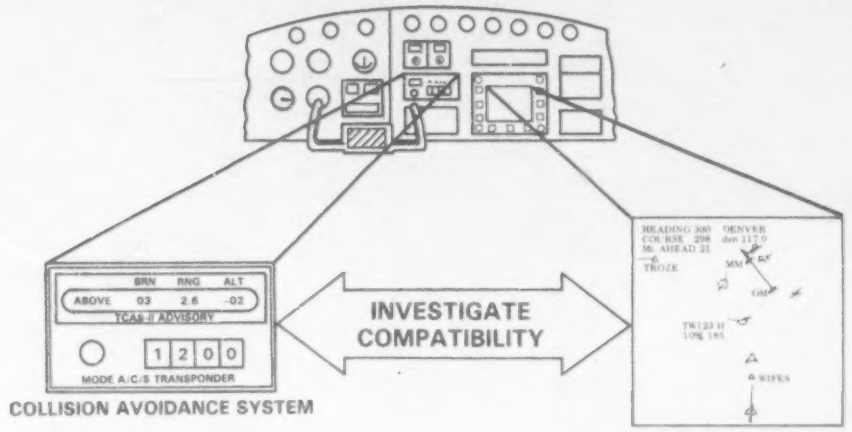
NASA

OAST NASA HQ RTB2 460(1) REV 2282

Figure 30

HUMAN FACTORS

COCKPIT DISPLAY INTERACTIONS



COLLISION AVOIDANCE SYSTEM

COCKPIT DISPLAY OF TRAFFIC INFORMATION

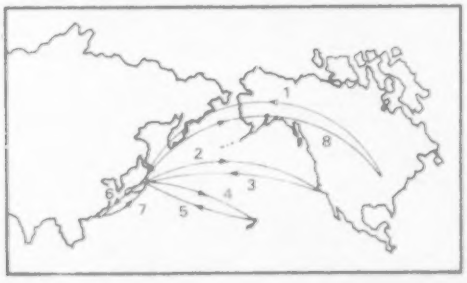
NASA

Figure 11

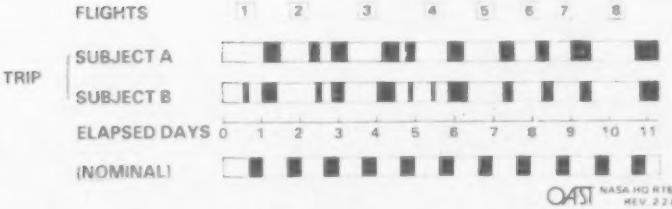
OAST NASA HQ RT82 46813 REV. 2 2 82

HUMAN FACTORS

CIRCADIAN DESYNCHRONOSIS



SLEEP-WAKE CYCLE DATA



NASA

Figure 12

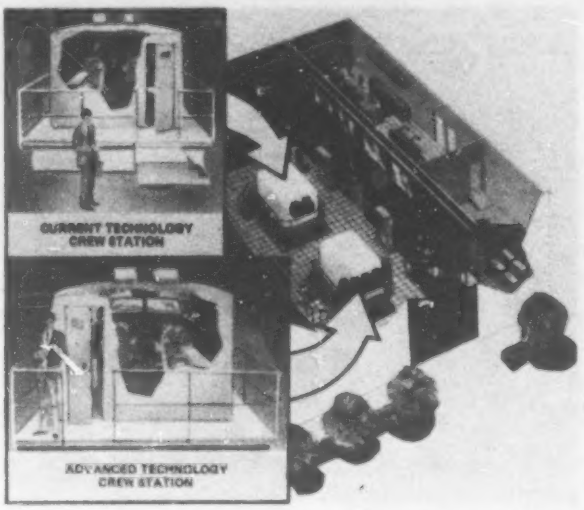
OAST NASA HQ RT82 46813 REV. 2 2 82

HUMAN FACTORS

MAN-VEHICLE SYSTEMS RESEARCH FACILITY (AMES)

OPERATIONAL
FY 83

OPERATIONAL
FY 84



NASA

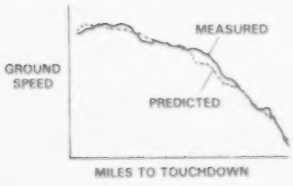
OAST NASA HQ R182 467(3) REV. 2 2 82

Figure 33

HUMAN FACTORS

CREW MODELING

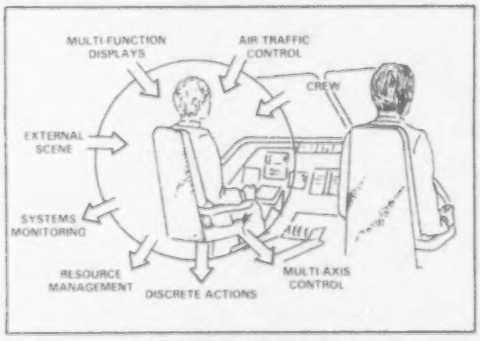
SINGLE-PILOT MODEL



COMPLETED

- PREDICTS SIMPLE CONTROL

COMPLEX MULTI-CREW MODEL



CURRENT THRUST

- PREDICT DECISIONS, ACTIONS AND ERRORS

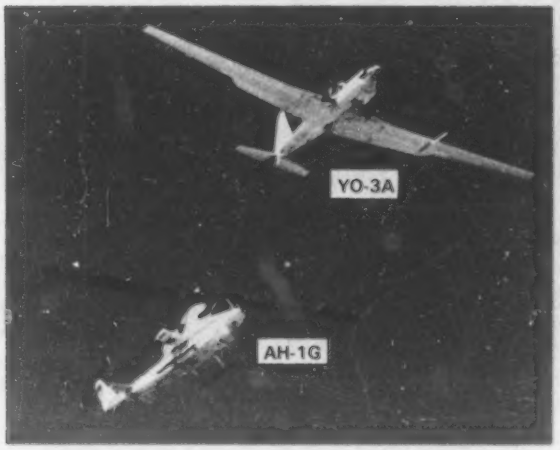
NASA

OAST NASA HQ R182 495(3) REV. 2 2 82

Figure 34

ROTORCRAFT

AEROACOUSTIC FLIGHT RESEARCH



- SIMULTANEOUSLY MEASURED ROTOR AIRLOADS (ON AH-1G) AND ROTOR IN-FLIGHT NOISE (BY YO-3A)
- CORRELATION WITH WIND-TUNNEL DATA

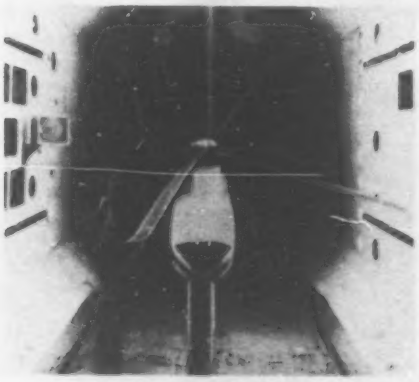
NASA

OAST NASA HQ (U82 478(3) REV. 2 2 82

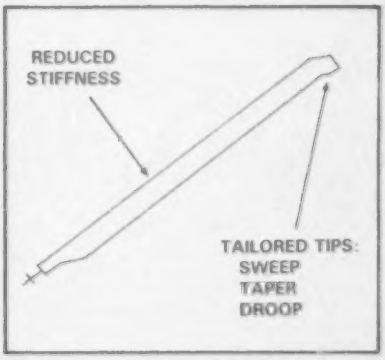
Figure 35

ROTORCRAFT

AEROELASTICALLY CONFORMABLE ROTOR CONCEPT



16-FT TRANSONIC DYNAMICS TUNNEL



BLADE CONCEPT

REDUCED VIBRATORY LOADS
IMPROVED PERFORMANCE

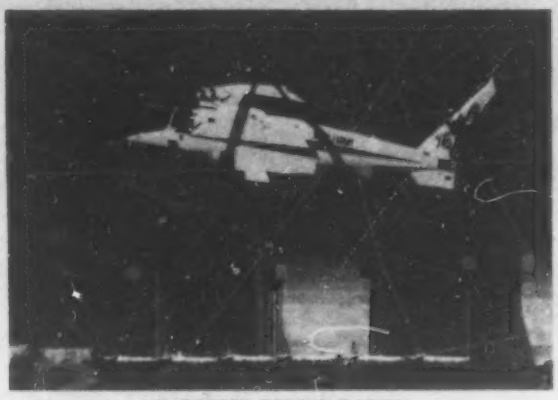
NASA

OAST NASA HQ (U82 480(3) REV. 2 2 82

Figure 36

ROTORCRAFT

ROTOR SYSTEMS RESEARCH AIRCRAFT



HELICOPTER CONFIGURATION

- ACCURATELY MEASURE
  - –ROTOR FORCES
  - –BLADE MOTIONS
  - –AIRCRAFT MOTIONS
- VERIFY AERODYNAMIC PREDICTION METHODS

NASA

OAST NASA HQ R.82 47(13) REV. 2 2 82

Figure 37

ROTORCRAFT

IMPROVED ROTOR TECHNOLOGY

ARMY/NASA PROGRAM

MODEL TEST SERIES

ALTERNATE ROTOR CONFIGURATIONS

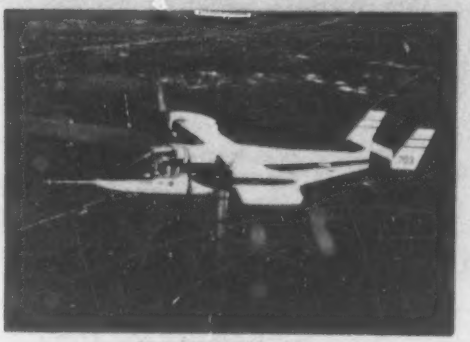
INCREASED PERFORMANCE CAPABILITY

NASA NASA HQ R.82 49(13) REV. 2 2 82 OAST

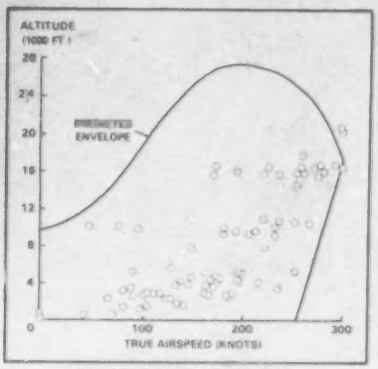
Figure 38

ROTORCRAFT

TILT ROTOR RESEARCH AIRCRAFT



XV-15 AIRCRAFT



XV-15 FLIGHT ENVELOPE

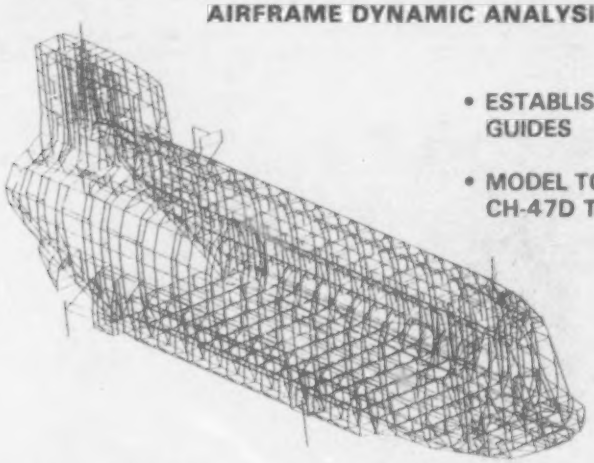
NASA

OAST NASA HQ RJ82 497(3) REV. 2 2 82

Figure 39

ROTORCRAFT

AIRFRAME DYNAMIC ANALYSIS



- ESTABLISHED INITIAL USER GUIDES
- MODEL TO BE VALIDATED WITH CH-47D TEST DATA

CH-47D NASTRAN STRUCTURAL MODEL

NASA

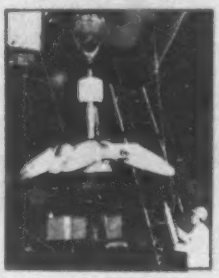
OAST NASA HQ RJ82 476(3) 1 15 82

Figure 40

ROTORCRAFT

LARGE TRANSMISSION TECHNOLOGY

SPIRAL BEVEL GEAR



XCH-62 AFT TRANSMISSION

FINITE ELEMENT ANALYSIS

TRANSMISSION TESTING

PREDICTION METHODOLOGY TO BE CORRELATED WITH GEAR TEST DATA

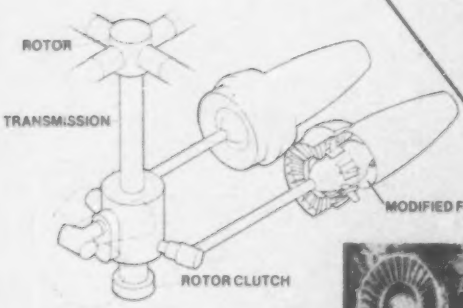
NASA

OAST NASA HQ RJB2 494(3) REV. 2.2.82

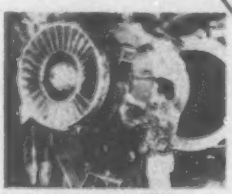
Figure 41

ROTORCRAFT

CONVERTIBLE ENGINE TECHNOLOGY

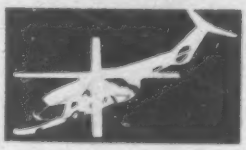


JOINT DARPA/ NASA PROGRAM



MODIFIED TF-34 ENGINE AS TEST BED

POTENTIAL APPLICATIONS



• X-WING

• ADVANCING BLADE CONCEPT (ABC)

• OTHER ADVANCED V/STOL CONCEPTS

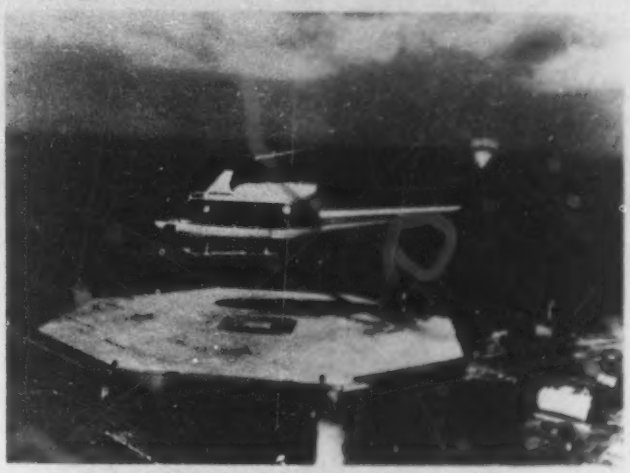
NASA

OAST NASA HQ RJB2 480(3) REV. 2.2.82

Figure 42

ROTORCRAFT

REMOTE SITE ALL-WEATHER OPERATIONS



AIRBORNE RADAR APPROACHES

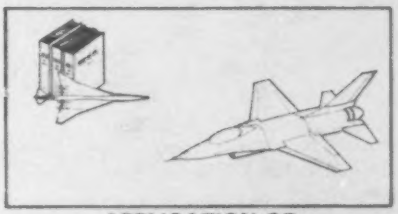
NASA

OAST

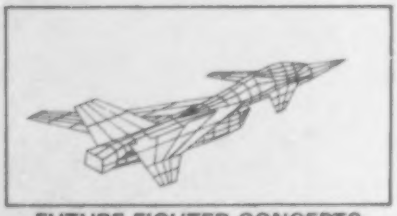
Figure 43

HIGH-SPEED AIRCRAFT

ADVANCED TACTICAL AIRCRAFT



APPLICATION OF SUPERSONIC CRUISE RESEARCH



FUTURE FIGHTER CONCEPTS

F-16E DEVELOPMENT SUPPORT

NASA

OAST

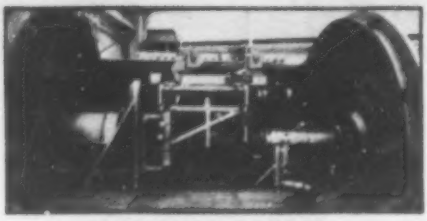
Figure 44

HIGH-SPEED AIRCRAFT

NON-AXISYMMETRIC NOZZLE RESEARCH

STUDIES

EXPLORATORY TESTS



LARGE SCALE TESTS

NASA

OAST NASA HQ IUBZ 451(3) REV 2 2 82

Figure 45

HIGH-SPEED AIRCRAFT

SUBSONIC V/STOL RESEARCH

AERODYNAMICS

FANS AND INLETS

SIMULATION

EXHAUST NOZZLES

NASA

Figure 46

OAST NASA HQ IUBZ 475(3) REV 2 2 82

HIGH-SPEED AIRCRAFT

SUPERSONIC V/STOL RESEARCH

STUDIES

TWIN ENGINE CONCEPTS IN LATE 1970'S

SINGLE ENGINE CONCEPTS IN 1981

WIND TUNNEL TESTS

- AERODYNAMICS
- CONTROLLABILITY
- PROPULSION/AIRFRAME INTERACTIONS

MODELS TO BE CONSTRUCTED AND TESTED

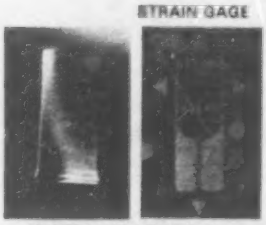
NASA

OAST

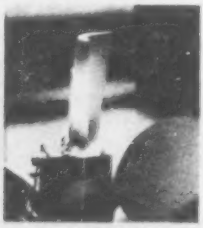
Figure 47

HIGH-SPEED AIRCRAFT

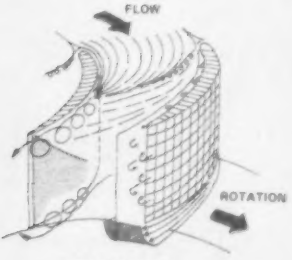
TURBINE ENGINE HOT SECTION TECHNOLOGY



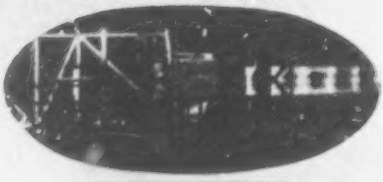
INSTRUMENTATION



TESTING



ANALYSIS

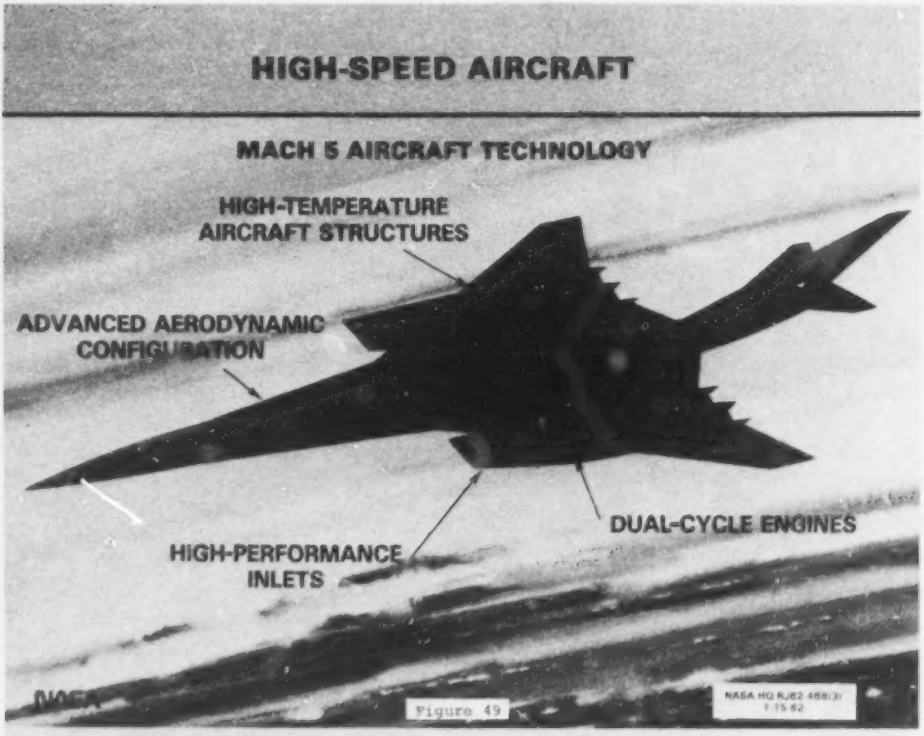


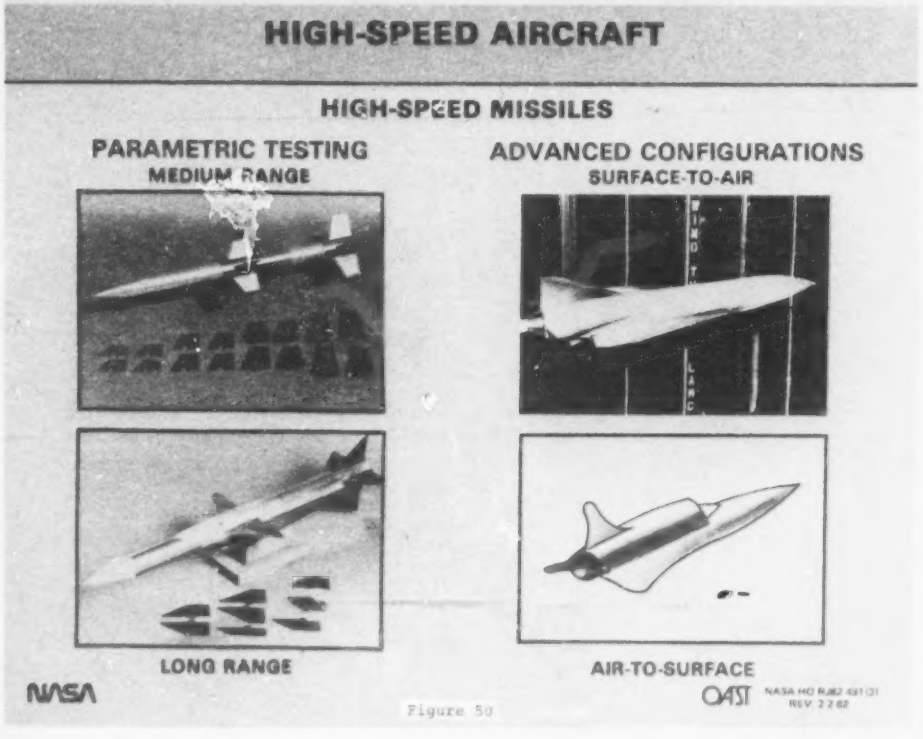
EXTENDED LIFE

NASA

OAST

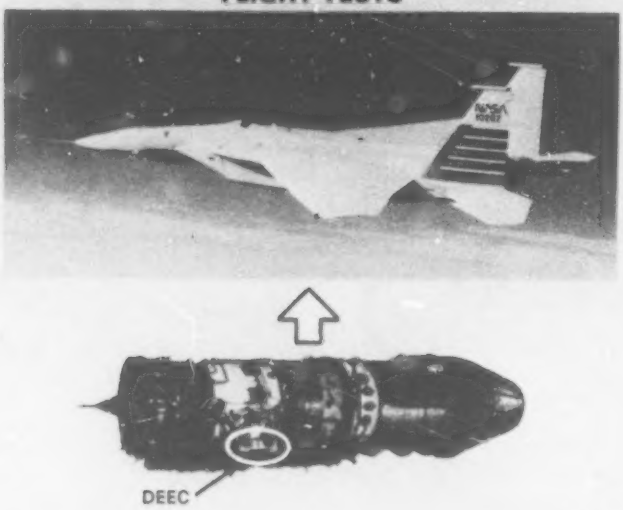
Figure 48


HIGH-SPEED AIRCRAFT
MACH 5 AIRCRAFT TECHNOLOGY
HIGH-TEMPERATURE AIRCRAFT STRUCTURES
ADVANCED AERODYNAMIC CONFIGURATION
DUAL-CYCLE ENGINES
HIGH-PERFORMANCE INLETS
NASA
Figure 49
NASA HQ RJ82 488(3)
1-15-82


HIGH-SPEED AIRCRAFT
HIGH-SPEED MISSILES
PARAMETRIC TESTING
MEDIUM RANGE
ADVANCED CONFIGURATIONS
SURFACE-TO-AIR
LONG RANGE
AIR-TO-SURFACE
NASA
OAST
Figure 50
NASA HQ RJ82 491(3)
REV. 2-2-82

HIGH-SPEED AIRCRAFT

DIGITAL ELECTRONIC ENGINE CONTROL (DEEC) FLIGHT TESTS



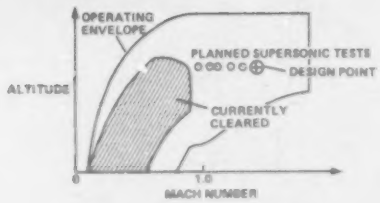
NASA

OAST NASA HQ RJ82 483(3) REV. 2 2 82

Figure 51

HIGH-SPEED AIRCRAFT

HIGHLY MANEUVERABLE AIRCRAFT TECHNOLOGY (HIMAT)



NASA

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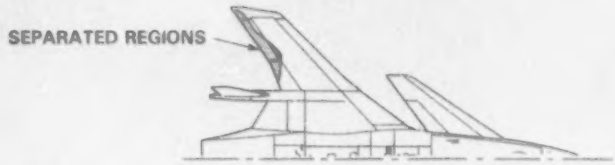
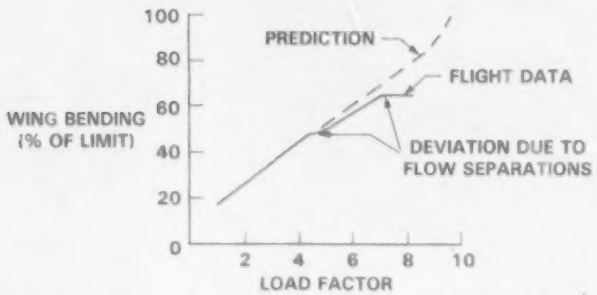
Figure 52

HIGH-SPEED AIRCRAFT

HiMAT LOADS RESEARCH





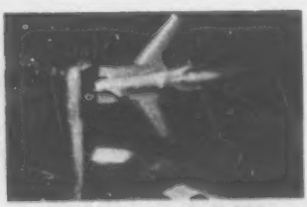
NASA

OAST NASA HQ RJ82 486(3) 1 15 82

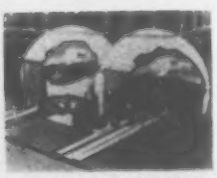
Figure 53

HIGH-SPEED AIRCRAFT

FORWARD SWEPT WING PROGRAM



AERODYNAMIC TESTS



FLYING QUALITIES

AERODYNAMIC TESTS

FLIGHT TESTS

NASA

OAST NASA HQ RJ82 492(3) REV 2 2 82

Figure 54

ACEE STATUS

ENERGY EFFICIENT ENGINE

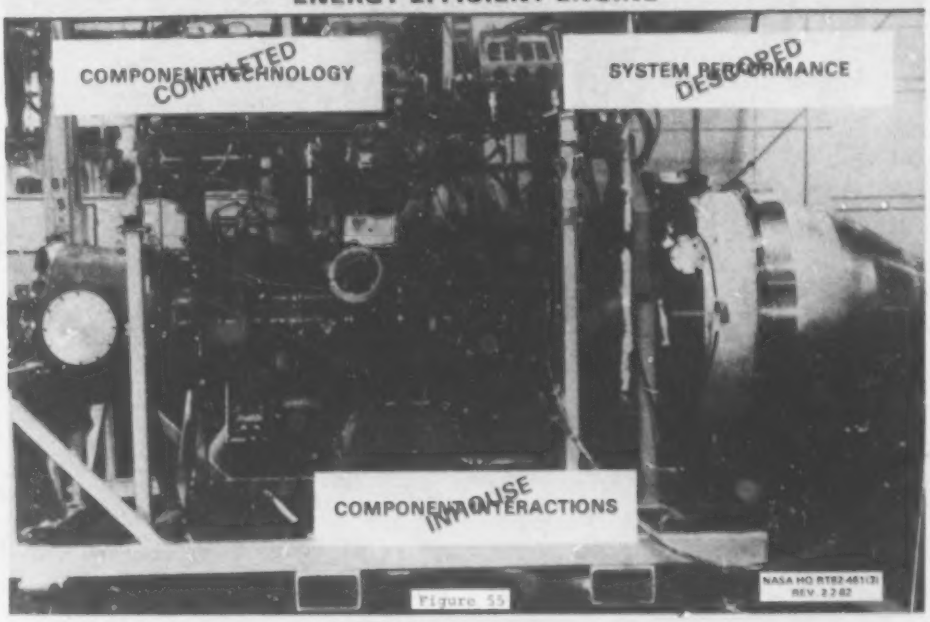


Figure 55

ACEE STATUS

ADVANCED TURBOPROP PROGRAM

FUEL SAVINGS POTENTIAL

- 15–20% RELATIVE TO TURBOFAN
- RECENT STUDIES CONFIRM SAVINGS

TECHNOLOGY AREA	PROGRAM STATUS		
	SUBSCALE	LARGE-SCALE	
		GROUND TEST	FLIGHT TEST
PROP-FAN			
• EFFICIENCY	COMPLETED	—	ELIMINATED
• FLUTTER	ONGOING	ELIMINATED	ELIMINATED
• STRUCTURE	PLANNED	DESCOPED	ELIMINATED
NOISE	ONGOING	DESCOPED	ELIMINATED
INSTALLATION	DESCOPED	—	ELIMINATED
ENGINE TECHNOLOGY	—	ELIMINATED	—

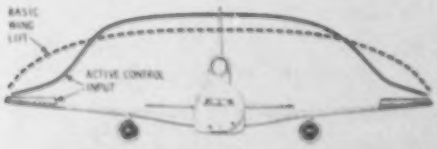
NASA

OAST NASA HQ RT82-461(3) REV 2 2 82

Figure 56

ACEE STATUS

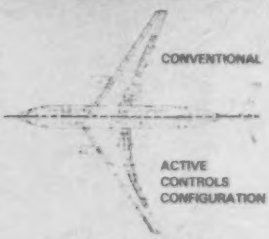
ENERGY EFFICIENT TRANSPORT



MANEUVER/GUST LOAD ALLEVIATION

SUPERCRITICAL AERODYNAMICS DATA BASE

WINGLETS



ACTIVE CONTROLS

NASA

Figure 57

OAST NASA HQ RT82-487(3) REV. 2 2-82

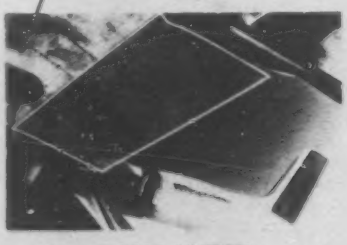
ACEE STATUS

COMPOSITE SECONDARY STRUCTURES

DC-10 RUDDER

WEIGHT REDUCTION	NUMBER UNITS	FAA CERTIFICATION
26.4%	20	MAY 1976
24.6%	11	JAN. 1980
23.6%	12	SEPT. 1981

727 ELEVATOR



L-1011 AILERON

NASA

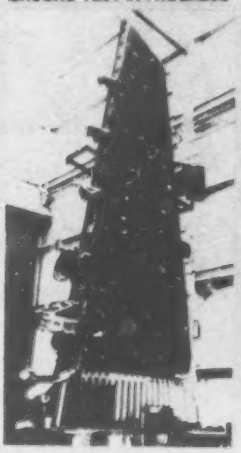
Figure 59

OAST NASA HQ RJ82 499(3) 1 19 82

ACEE STATUS

COMPOSITE PRIMARY STRUCTURES

L-1011 VERTICAL FIN
28% WEIGHT SAVED
GROUND TEST IN PROGRESS



DC-10 VERTICAL STABILIZER
23% WEIGHT SAVED; GROUND TEST IN PROGRESS

737 HORIZONTAL STABILIZER
22% WEIGHT SAVED; AWAITING FAA CERTIFICATION

NASA

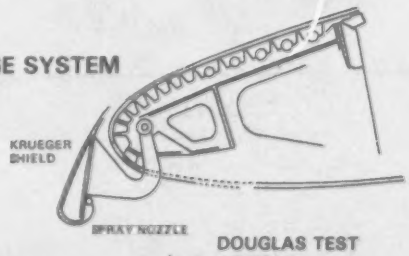
OAST NASA HQ RJ82 484(3) REV. 2.2.82

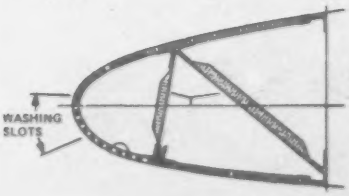
Figure 59

ACEE STATUS

LAMINAR FLOW CONTROL PROGRAM

LEADING EDGE SYSTEM FLIGHT TEST





LOCKHEED TEST ARTICLE

DOUGLAS TEST ARTICLE

FY 1983 JETSTAR FLIGHT TEST

NASA

OAST NASA HQ RJ82 485(3) REV. 2.2.82

Figure 60

APPENDIX

RESPONSES TO WRITTEN QUESTIONS SUBMITTED BY THE CHAIRMAN, SUBCOMMITTEE ON TRANSPORTATION, AVIATION, AND MATERIALS

QUESTION 1:

Please tabulate the FY 1982 Operating Plan for Aeronautics showing any changes from the initial plan (budget request).

ANSWER:

The $323.6 million FY 1982 budget submitted in January 1981 to the Congress for Aeronautical Research and Technology was resubmitted as an amended budget totaling $264.8 million in March 1981. Recent actions further reducing the FY 1982 NASA appropriation have resulted in an additional $31.8 million decrease in this program.

The reduction of $31.8 million is the result of implementation of the policy decision to emphasize fundamental research and technology while de-emphasizing technology demonstration activities. This de-emphasis in systems technology reflects the objective of reducing the Federal role in those areas which directly support industry for commercial product development, while retaining those efforts which are related to longer range technology and to defense considerations.

The current FY 1982 Aeronautics budget total is $233.0 million. A tabular summary follows:

FY 1982 BUDGET CHRONOLOGY
($ in Millions)

Original Submission	323.6
Budget Amendment	- 58.8
Amended Submission	264.8
Reduction	- 31.8
Current 1982 Operating Plan	233.0

A detailed comparison of the FY 1982 Amended Budget and the current FY 1982 Operating Plan is enclosed.

FY 1982 AERONAUTICS OPERATING PLAN
BUDGET VS. CURRENT PLAN
($ in Thousands)

	BUDGET (MARCH)	△	CURRENT	EXPLANATION OF DIFFERENCES
Aeronautics	$264,800	-$31,800	$233,000	
Research and Technology (R&T) Base	157,800	+4,700	162,500	Reflects transfer of $2.5M to the R&T Base to do priority supersonic cruise research; and an increase of $2.2M in critical resources activity to expand the R&T Base emphasis on alternative fuels research.
Aerodynamics R&T	27,200	+2,000	29,200	Reflects increased emphasis on cryogenic research and realignment of funding from other aeronautical activities to support fundamental supersonic aerodynamics research.
Propulsion R&T	35,300	+1,800	37,100	Reflects internal program redirection to support additional emphasis in critical resources, supersonic cruise research and small engine research, with a reduction in turbofan noise research.

	BUDGET (MARCH)	△	CURRENT	EXPLANATION OF DIFFERENCES
Materials and Structures R&T	21,800	+300	22,100	Reflects an increased emphasis on supersonic cruise, the inclusion of general aviation interior noise activity, and a decreased emphasis on materials life prediction research.
Aircraft Controls & Guidance R&T	7,100	-100	7,000	Minor realignment within the R&T Base in order to support other priority R&T Base requirements.
Human Factors R&T	8,100	-100	8,000	Decrease resulted primarily from a de-emphasis in the human response to noise effort in order to support other priority efforts within the R&T Base.
Multidisciplinary Research	5,900	+100	6,000	Reflects a modest increase for post-baccalaureate program to offset cost adjustments.
General Aviation and Commuter R&T	7,800	-100	7,700	Primarily reflects the transfer of the interior noise research program from general aviation to the materials and structures effort within the R&T Base.

	BUDGET (MARCH)	△	CURRENT	EXPLANATION OF DIFFERENCES
Low-Speed R&T	15,200	-3,900	11,300	Reflects realignment of $3.5M between low-speed and high-speed programs within the R&T Base associated with the transfer of budget and management responsibility of the high-performance V/STOL research activity to the high-speed program. The balance ($0.4M) resulted from a reduction to the rotorcraft avionics effort.
High-Speed R&T	20,700	+5,300	26,000	This increase resulted from the transfer of the powered-lift research and technology program ($3.5M) from the low-speed R&T Base program and from a rebalancing of the 1982 Aeronautics program which provided an additional $1.8M to this budget category for fundamental supersonic research in this area.
Transport R&T	8,700	-600	8,100	Primarily reflects a reduction in scope in analyses of transport aircraft recorder data.

	BUDGET (MARCH)	△	CURRENT	EXPLANATION OF DIFFERENCES
Systems Technology Programs	$107,000	-$36,500	$70,500	
Aeronautical Systems Studies	3,800	-3,800	--	Reflects a decision to eliminate aeronautical systems studies as an independent line item and a decision to conduct studies within the R&T Base disciplines and Systems Technology programs supported by the studies at a reduced level.
Materials & Structures Systems Technology	7,100	-500	6,600	Reflects the phase down and termination of the integrated program for aerospace vehicle design and the aeroelasticity of turbine engines program.
Propulsion Systems Technology	3,000	-2,500	500	Reflects deletion of the broad property fuels program and transfer of the funds to the R&T Base propulsion discipline for support of critical aircraft resources technology and completion of the braod property fuels effort, as well as phase down of the helicopter transmission technology activity which will be terminated in 1982.
Avionics & Flight Controls Systems Technology	1,300	--	1,300	

	BUDGET (MARCH)	△	CURRENT	EXPLANATION OF DIFFERENCES
Low-Speed Aircraft Systems Technology	30,900	-5,300	25,600	Reflects a decision to phase down powered-lift and tilt rotor systems technology activities in FY 1982 and to stretch out portions of the advanced rotorcraft project.
High-Speed Aircraft Systems Technology	7,700	--	7,700	
Transport Aircraft Systems Technology	27,400	-14,000	13,400	Changes to this program include the addition of $0.5M to enhance the composite primary aircraft structures activities; a decrease of $2.5M in the laminar flow control program; a decrease of $5.4M in the energy efficient transport effort and a reduction of $6.6M in the terminal configured vehicle program. The reduction reflects a planned phase out in 1982.
Advanced Propulsion Systems Technology	25,800	-10,400	15,400	Reflects descoping of the energy efficient engine program which was decreased by $7.9M and the advanced turboprop program which was reduced by $2.5M. These reductions indicate the phase out of these activities in 1982.

QUESTION 2:

Please tabulate for fiscal years 1981 through 1987 runout costs of the current aeronautics program (broken out by standard budget subline items as presented in the R&D budget book). Also, please provide figures for one budget level below these subline items.

ANSWER:

See the enclosed table.

FY 1983 AERONAUTICS BUDGET
($ in Millions)

	FY 81	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87
Aeronautics Research and Technology	271.4	233.0	232.0	232.7	228.0	220.5	219.2
505 Research and Technology Base	133.8	162.5	182.0	182.0	182.0	182.0	182.0
Systems Technology Programs	137.6	70.5	50.0	50.7	46.0	38.5	37.2
510 Materials and Structures Systems Technology	8.7	6.6	-	-	-	-	-
510-53 Materials for Advanced Turbine Engines	0.5	-	-	-	-	-	-
510-54 Integ. Prog. for Aerospace Veh. Design	5.0	1.3	-	-	-	-	-
510-55 Aeroelasticity of Turbine Engines	0.7	0.3	-	-	-	-	-
510-57 Turbine Engine Hot Section Technology	2.5	5.0	-	-	-	-	-
511 Propulsion Systems Technology	4.4	0.5	-	-	-	-	-
511-55 Advanced Low-Emission Combustion	0.2	-	-	-	-	-	-
511-58 Helicopter Transmission Technology	1.7	0.5	-	-	-	-	-
511-59 Broad Property Fuels Technology	2.5	-	-	-	-	-	-
512 Avionics and Flight Control Sys. Tech.	1.2	1.3	-	-	-	-	-
512-54 Advanced Guidance and Control Systems	1.2	1.3	-	-	-	-	-
530 Aeronautical Systems Studies	3.1	-	-	-	-	-	-
531 General Aviation Systems Technology	1.1	-	-	-	-	-	-
531-01 General Aviation Advanced Avionics	0.3	-	-	-	-	-	-
531-02 G.A./Commuter A/C Propeller Tech.	0.8	-	-	-	-	-	-
532 Low-Speed Aircraft Systems Technology	23.5	25.6	30.0	27.4	22.7	15.2	13.9
532-01 Rotorcraft Operating Systems	0.9	1.4	1.5	1.5	1.5	1.5	1.5
532-02 Powered-Lift Technology	1.7	0.3	-	-	-	-	-
532-03 Advanced Rotor Sys. Tech./RSRA Operations	6.1	6.4	5.6	3.0	3.0	3.0	3.0
532-04 THRA Systems Technology	0.8	1.0	-	-	-	-	-
532-05 V/STOL Systems Technology	2.6	-	-	-	-	-	-
532-06 Advanced Rotorcraft Technology	3.5	7.8	13.5	13.5	8.8	1.3	-
532-07 Low-Speed Simulation & Flt. Sys. Support	7.9	8.7	9.4	9.4	9.4	9.4	9.4
533 High-Speed Aircraft Systems Technology	16.6	7.7	20.0	23.3	23.3	23.3	23.3
533-01 Supersonic Cruise Research	10.8	-	-	-	-	-	-
533-02 High-Performance Flight Research	4.1	6.3	13.3	13.0	13.0	13.0	13.0
533-03 Highly-Maneuverable Aircraft Tech.	1.7	1.4	1.1	-	-	-	-
533-04 Turbine Engine Hot Section Tech.(Prev.510-57)	-	-	5.6	10.3	10.3	10.3	10.3
534 Transport Aircraft Systems Technology	32.8	13.4	-	-	-	-	-
534-01 Laminar Flow Control	4.6	4.0	-	-	-	-	-
534-02 Energy Efficient Transport	14.9	3.0	-	-	-	-	-
534-03 Composite Primary Aircraft Structures	6.1	4.9	-	-	-	-	-
534-04 Terminal Configured Vehicle	7.2	1.5	-	-	-	-	-
535 Advanced Propulsion Systems Technology	46.2	15.4	-	-	-	-	-
535-01 Energy Efficient Engine	36.8	11.2	-	-	-	-	-
535-02 Variable Cycle Engine Technology	6.3	-	-	-	-	-	-
535-03 Advanced Turboprop Systems	3.1	4.2	-	-	-	-	-

QUESTION 3:

Please tabulate, for fiscal years 1981 through 1987, runout costs of the current aeronautics program (broken out in the following categories: CTOL (non ACEE), CTOL (ACEE), General Aviation, Rotorcraft, VTOL, STOL, Commuter Aircraft, High Performance, Supersonic, Hypersonic, and Generic R&T). Also, to permit relating this to the standard budget sublines, please provide a further breakout, for each category, showing funds included in the R&T Base, and the various Systems Technology Programs identified by budget sub-line item and further identified by program (e.g. Transport Aircraft System Technology under ACEE, and EET under Transport Aircraft System Technology).

ANSWER:

See the enclosed table.

AERONAUTICAL RESEARCH AND TECHNOLOGY
SPECIAL ANALYSIS
($ in Millions)

	FY 81	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87
Transport Aircraft (Non-ACEE)	15.4	9.6	8.8	8.8	8.8	8.8	8.8
Research and Technology Base	7.1	8.1	8.8	8.8	8.8	8.8	8.8
Transport Aircraft R&T	7.1	8.1	-	-	-	-	-
Materials and Structures R&T	-	-	5.8	5.8	5.8	5.8	5.8
Aircraft Controls and Guidance R&T	-	-	3.0	3.0	3.0	3.0	3.0
Transport Aircraft Sys. Tech.	7.2	1.5	-	-	-	-	-
Terminal Configured Vehicle	7.2	1.5	-	-	-	-	-
Aeronautical Systems Studies	1.1	-	-	-	-	-	-
Transport Aircraft (ACEE)	65.5	27.3	-	-	-	-	-
Transport Aircraft Sys. Tech.	25.6	11.9	-	-	-	-	-
Laminar Flow Control	4.6	4.0	-	-	-	-	-
Energy Efficient Transport	14.9	3.0	-	-	-	-	-
Composite Primary A/C Struct.	6.1	4.9	-	-	-	-	-
Advanced Propulsion Sys. Tech.	39.9	15.4	-	-	-	-	-
Energy Efficient Engine	36.8	11.2	-	-	-	-	-
Advanced Turboprop Systems	3.1	4.2	-	-	-	-	-

	FY 81	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87
General Aviation	8.1	7.7	6.5	6.5	6.5	6.5	6.5
Research and Technology Base	6.6	7.7	6.5	6.5	6.5	6.5	6.5
General Aviation and Commuter R&T	6.6	7.7	-	-	-	-	-
Propulsion R&T	-	-	3.5	3.5	3.5	3.5	3.5
Aerodynamics R&T	-	-	2.0	2.0	2.0	2.0	2.0
Materials and Structures R&T	-	-	1.0	1.0	1.0	1.0	1.0
General Aviation Sys. Tech.	1.1	-	-	-	-	-	-
Aeronautical Systems Studies	0.4	-	-	-	-	-	-
Rotorcraft	29.3	36.6	42.4	39.8	35.1	27.6	26.3
Low-Speed R&T Base	9.6	11.3	12.4	12.4	12.4	12.4	12.4
Low-Speed Aircraft Sys. Tech.	19.2	25.3	30.0	27.4	22.7	15.2	13.9
Rotorcraft Operating Systems	0.9	1.4	1.5	1.5	1.5	1.5	1.5
Adv. Rotor Systems/RSRA Ops.	6.1	6.4	5.6	3.0	3.0	3.0	3.0
TRRA Systems Tech.	0.8	1.0	-	-	-	-	-
Advanced Rotorcraft Tech.	3.5	7.8	13.5	13.5	8.8	1.3	-
Low-Speed Simulation & Flight System Support	7.9	8.7	9.4	9.4	9.4	9.4	9.4
Aeronautical Systems Studies	0.5	-	-	-	-	-	-

	FY 81	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87
STOL	1.7	0.3	-	-	-	-	-
Low-Speed Aircraft Sys. Tech.	1.7	0.3	-	-	-	-	-
Powered-Lift Technology	1.7	0.3	-	-	-	-	-
High-Performance	29.5	38.7	47.0	50.3	50.3	50.3	50.3
High-Speed R&T Base	20.6	26.0	27.0	27.0	27.0	27.0	27.0
(V/STOL included)	(3.1)	(3.5)	(3.5)	(3.5)	(3.5)	(3.5)	(3.5)
High-Speed Aircraft Sys. Tech.	5.8	7.7	20.0	23.3	23.3	23.3	23.3
High-Performance Flight Research	4.1	6.3	13.3	13.0	13.0	13.0	13.0
Highly Maneuverable A/C Tech.	1.7	1.4	1.1	-	-	-	-
Turbine Engine Hot Section Tech.	-	-	5.6	10.3	10.3	10.3	10.3
Materials & Structures Sys. Tech.	2.5	5.0	-	-	-	-	-
Turbine Engine Hot Section Tech.	2.5	5.0	-	-	-	-	-
Aeronautical Systems Studies	0.6	-	-	-	-	-	-
Supersonic *	17.1	-	-	-	-	-	-
High-Speed Aircraft Sys. Tech.	10.8	-	-	-	-	-	-
Supersonic Cruise Research	10.8	-	-	-	-	-	-
Advanced Propulsion Sys. Tech.	6.3	-	-	-	-	-	-
Variable Cycle Engine Tech.	6.3	-	-	-	-	-	-
Generic	104.8	112.8	127.3	127.3	127.3	127.3	127.3
TOTAL	271.4	233.0	232.0	232.7	228.0	220.5	219.2

Funding for the following categories is included in the R&T Base or Systems Technology programs indicated and, therefore, is nonadditive:

	FY 81	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87
Supersonic*	17.1	5.9	5.9	5.9	5.9	5.9	5.9
Aerodynamics R&T Base	-	1.0	1.0	1.0	1.0	1.0	1.0
Propulsion R&T Base	-	1.7	1.7	1.7	1.7	1.7	1.7
Materials & Struct. R&T Base	-	1.2	1.2	1.2	1.2	1.2	1.2
High-Speed R&T Base	-	2.0	2.0	2.0	2.0	2.0	2.0
High-Speed Aircraft Sys. Tech.	10.8	-	-	-	-	-	-
Supersonic Cruise Research	10.8	-	-	-	-	-	-
Advanced Propulsion Sys. Tech.	6.3	-	-	-	-	-	-
Variable Cycle Engine Tech.	6.3	-	-	-	-	-	-
Hypersonic	4.5	4.2	4.3	4.3	4.3	4.3	4.3
Aerodynamics R&T Base	0.8	0.5	0.5	0.5	0.5	0.5	0.5
Propulsion R&T Base	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Materials & Struct. R&T Base	0.5	0.5	0.6	0.6	0.6	0.6	0.6
High-Speed R&T Base	0.9	0.9	0.9	0.9	0.9	0.9	0.9

* Focused supersonic program terminated in 1981; fundamental research in the supersonic area included in various R&T Base disciplines beginning in 1982.

	FY 81	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87
Commuter Aircraft	6.7	7.1	2.4	2.4	2.4	2.4	2.4
General Aviation & Commuter R&T Base	2.3	2.9	2.4	2.4	2.4	2.4	2.4
General Aviation Sys. Tech.	0.8	-	-	-	-	-	-
General Aviation/Commuter Aircraft Propeller Technology	0.8	-	-	-	-	-	-
Aeronautical Systems Studies	0.5	-	-	-	-	-	-
Advanced Turboprop Systems	3.1	4.2	-	-	-	-	-

QUESTION 4:

Please provide a tabulation for each large development program (former experimental programs plus new efforts of comparable scope) showing:

a. Original estimated date of completion and cost
b. Estimated date and cost of completion furnished to the Subcommittee last year
c. Current estimates
d. Reasons for change from last year.

ANSWER:

See the enclosed table.

MAJOR AERONAUTICS PROGRAMS: TOTAL COST/SCHEDULE CHRONOLOGY
($ in Millions)

	ORIGINAL ESTIMATE		JAN. 1981 ESTIMATE		CURRENT ESTIMATE		
	DATE OF COMPLETION	COST	DATE OF COMPLETION	COST	DATE OF COMPLETION	COST	REASON FOR CHANGE FROM LAST YEAR
Energy Efficient Engine	1983	178.9	12/84	200.6	1982	173.9	The overall reduction of $26.7M includes FY 1982 decreases of $3.0M due to the 1982 budget amendment; a $4.0M decrease in order to fund other high priority aeronautics requirements; and a decrease of an additional $3.9M due to the recently directed Agency-wide budget reduction. The balance of the reduction reflects the decision to terminate the program at the end of 1982.
Highly Maneuverable Aircraft Technology	1/78	18.1	3/82	24.8	1983	27.5	Due to difficulties encountered during the initial phase of the flight test program, the date for completion was extended two years. The increase reflects the additional costs associated with extension of the program.
Composite Primary Aircraft Structures	1985	147.5	12/83	94.4	1982	92.9	The overall reduction of $1.5M reflects two actions: an increase of $0.5M in FY 1982 to enhance technology gains and the decision to terminate the program at the end of 1982.

QUESTION 5:

Please provide quantitative data that traces the development of the FY 1983 budget request. Specifically, please show initial and final OAST recommendations, the submission to OMB and the request to Congress for new initiatives.

ANSWER:

See the enclosed table.

CHRONOLOGY OF FY 1983 AERONAUTICS BUDGET
($ in Millions)

	OAST RECOMMENDATION	SUBMISSION TO OMB	MIN. LEVEL SUBMISSION TO OMB	SUBMISSION TO CONGRESS
ONGOING	330.7	319.0	296.0	232.0
R&T Base	199.5	203.8	203.5	182.0
Systems Technology	131.2	115.2	92.5	50.0
Materials & Structures Systems Technology	3.1	3.1	0.1	-
Propulsion Systems Technology	10.7	5.7	4.2	-
Aero. Systems Studies	4.2	2.9	2.9	-
Low-Speed Aircraft Systems Technology	46.8	38.8	38.3	30.0
High-Speed Aircraft Systems Technology	20.5	20.5	19.5	20.0
Transport Aircraft Systems Technology	18.7	17.4	10.7	-
Advanced Propulsion Systems Technology	27.2	26.8	16.8	-
NEW INITIATIVES	89.8	52.0	-	-
R&T Base Augmentation	8.5	8.0	-	-
Numerical Aerodynamic Simulator	10.0	-	-	-
Productivity Improvement	24.3	6.0	-	-
Small Engine Components	3.0	3.0	-	-
Transport A/C Composite Structures	4.0	4.0	-	-
Advanced Turboprop Phase 3 Acceleration	31.0	31.0	-	-
Quiet, Efficient Rotorcraft Technology	9.0	-	-	-
TOTAL	420.5	371.0	296.0	232.0

QUESTION 6:

Please provide the budget "levels" broken out by sub-line item, for fiscal years 1983 through 1987 that comprised the OMB FY 83 ZBB package. Also, please provide brief descriptions of the work in each level.

ANSWER:

The ZBB process was not used in formulating the FY 1983 budget submission to OMB; however, the NASA recommended budget submission was $371.0 million. At OMB's request, a reduced level budget of $296.0 million was provided. The details of these two budget levels are reflected in the enclosed tables.

AERONAUTICAL RESEARCH AND TECHNOLOGY
FY 1983 OMB BUDGET SUBMISSION
($ in Millions)

REQUESTED LEVEL	FY 83	FY 84	FY 85	FY 86	FY 87	Description
Aeronautical Research & Technology	371.0	391.4	377.0	353.8	326.0	
Ongoing Program	319.0	299.4	293.0	276.8	272.0	
Research and Technology Base	203.8	203.8	203.8	203.8	203.8	Generic and vehicle-oriented research technology and $4.0M for continuing studies for the Numerical Aerodynamic Simulator
Materials and Structures Systems Technology*	3.1	4.5	4.5	3.5	1.5	Integrated Program for Aerospace Vehicle Design and Aeroelasticity of Turbine Engines
Propulsion Systems Technology	5.7	14.8	11.9	11.9	11.9	Helicopter Transmission Technology and Broad Property Fuels/Critical Aircraft Resources
Aeronautical Systems Studies	2.9	4.2	4.2	4.2	4.2	Vehicle-specific and total national airspace system studies to assess the integration of current and future technologies with economic and social considerations
Low-Speed Aircraft Systems Technology	38.8	25.6	24.7	17.2	15.9	Rotorcraft and flight investigations, including simulation and flight systems support

REQUESTED LEVEL	FY 83	FY 84	FY 85	FY 86	FY 86	Description
Ongoing Program (Continued)						
High-Speed Aircraft Systems Technology*	20.5	19.9	19.7	20.6	19.1	High-Performance Flight Research, Highly Maneuverable Aircraft Technology and Turbine Engine Hot Section Technology
Transport Aircraft Systems Technology	17.4	15.6	15.6	15.6	15.6	Laminar Flow Control, Energy Efficient Transport, Composite Primary Aircraft Structures, and Terminal Configured Vehicle
Advanced Propulsion Systems Technology	26.8	11.0	8.6	-	-	Energy Efficient Engine and Advanced Turboprop Systems
New Initiatives	52.0	92.0	84.0	77.0	54.0	
Research and Technology Base	14.0	14.0	14.0	14.0	14.0	
Augmentation	8.0	8.0	8.0	8.0	8.0	Included: 1) Advanced Composites Research for both airframe and engine applications ($4M) and 2) High-Performance Research ($4M)

*Turbine Engine Hot Section Technology transferred to High-Speed Aircraft Systems Technology from Materials and Structures Systems Technology subsequent to budget submission to OMB.

REQUESTED LEVEL	FY 83	FY 84	FY 85	FY 86	FY 87	Description
Research and Technology Base (Continued)						
Facility Productivity Improvement	6.0	6.0	6.0	6.0	6.0	Modernization of the existing aeronautical facilities at the Research Centers to provide for more efficient use and greater output
Propulsion Systems Technology	3.0	6.0	10.0	12.0	10.0	
Small Engine Technology	3.0	6.0	10.0	12.0	10.0	Advanced component technology development for small centrifugal/ axial gas turbine engines for rotorcraft and general aviation applications
Transport Aircraft Systems Technology	4.0	16.0	19.0	18.0	12.0	
Transport Aircraft Composite Structures	4.0	16.0	19.0	18.0	12.0	This program was to address critical technical problems in applying composite materials to large primary wing structures, with technology development carried through fabrication of full-sized partial wing box sections for subsequent in-house testing. This was intended to be a cooperative program with industry, Federal Aviation Administration and Department of Defense

REQUESTED LEVEL	FY 83	FY 84	FY 85	FY 86	FY 87	Description
New Initiatives (Continued)						
Advanced Propulsion Systems Technology	31.0	56.0	41.0	33.0	18.0	
Advanced Turboprop Phase III Acceleration	31.0	56.0	41.0	33.0	18.0	Acceleration of Phase III of the Advanced Turboprop Systems program to provide usable and verified design technology, at least one year sooner than the basic plan, and increased emphasis on engine/gear-box integration and installation efforts

AERONAUTICAL RESEARCH AND TECHNOLOGY
FY 1983 OMB BUDGET SUBMISSION
($ in Millions)

MINIMUM LEVEL	FY 83	FY 84	FY 85	FY 86	FY 87	Description
Aeronautical Research and Technology	296.0	284.9	279.8	265.1	263.8	
Research and Technology Base	203.5	203.5	203.5	203.5	203.5	Generic and vehicle-oriented research and technology and $4.0M for continuing studies for the Numerical Aerodynamic Simulator
Materials and Structures Systems Technology*	0.1	-	-	-	-	Integrated Program for Aerospace Vehicle Design
Propulsion Systems Technology	4.2	13.3	11.9	11.9	11.9	Broad Property Fuels/Critical Aircraft Resources
Aeronautical Systems Studies	2.9	4.2	4.2	4.2	4.2	Vehicle-specific and total national airspace system studies to assess integration of current and future technologies with economic and social considerations
Low-Speed Aircraft Systems Technology	38.3	25.9	25.0	17.5	16.2	Rotorcraft and flight investigations, including simulation and flight systems support
High-Speed Aircraft Systems Technology*	19.5	18.1	17.7	19.1	19.1	High-performance flight research, highly maneuverable aircraft technology and turbine engine hot section technology

MINIMUM LEVEL (Continued)	FY 83	FY 84	FY 85	FY 86	FY 87	Description
Transport Aircraft Systems Technology	10.7	8.9	8.9	8.9	8.9	Energy efficent transport, composite primary aircraft structures and terminal configured vehicle program (Only terminal configured vehicle program is reflected beyond FY 1983.)
Advanced Propulsion Systems Technology	16.8	11.0	8.6	-	-	Energy efficient engine and advanced turboprop systems (Only advanced turboprop systems program is reflected beyond FY 1983.)

* Turbine Engine Hot Section Technology transferred to High-Speed Aircraft Systems Technology from Materials and Structures Systems Technology subsequent to budget submission to OMB.

QUESTION 7:

How much is contained in the Fiscal 1983 request for alternative fuels utilization research, aircraft noise research, wake vortex alleviation, heads-up display research, Cockpit Display of Traffic Information, scarce materials research, human factors, avionics, and controls?

ANSWER:

	FY 1983 ($ in Millions)
Alternative fuels research	2.4
Aircraft noise research*	9.9
Wake vortex alleviation	0.6
Heads-up display research	-
Cockpit display of traffic information	1.3
Scarce materials research	1.5
Human factors	10.5
Avionics	5.5
Controls	8.1

* This includes noise research for rotorcraft and turboprop powered aircraft.

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